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The Grand Fir/Blue Huckleberry Habitat Type in Central Idaho: Succession and Management

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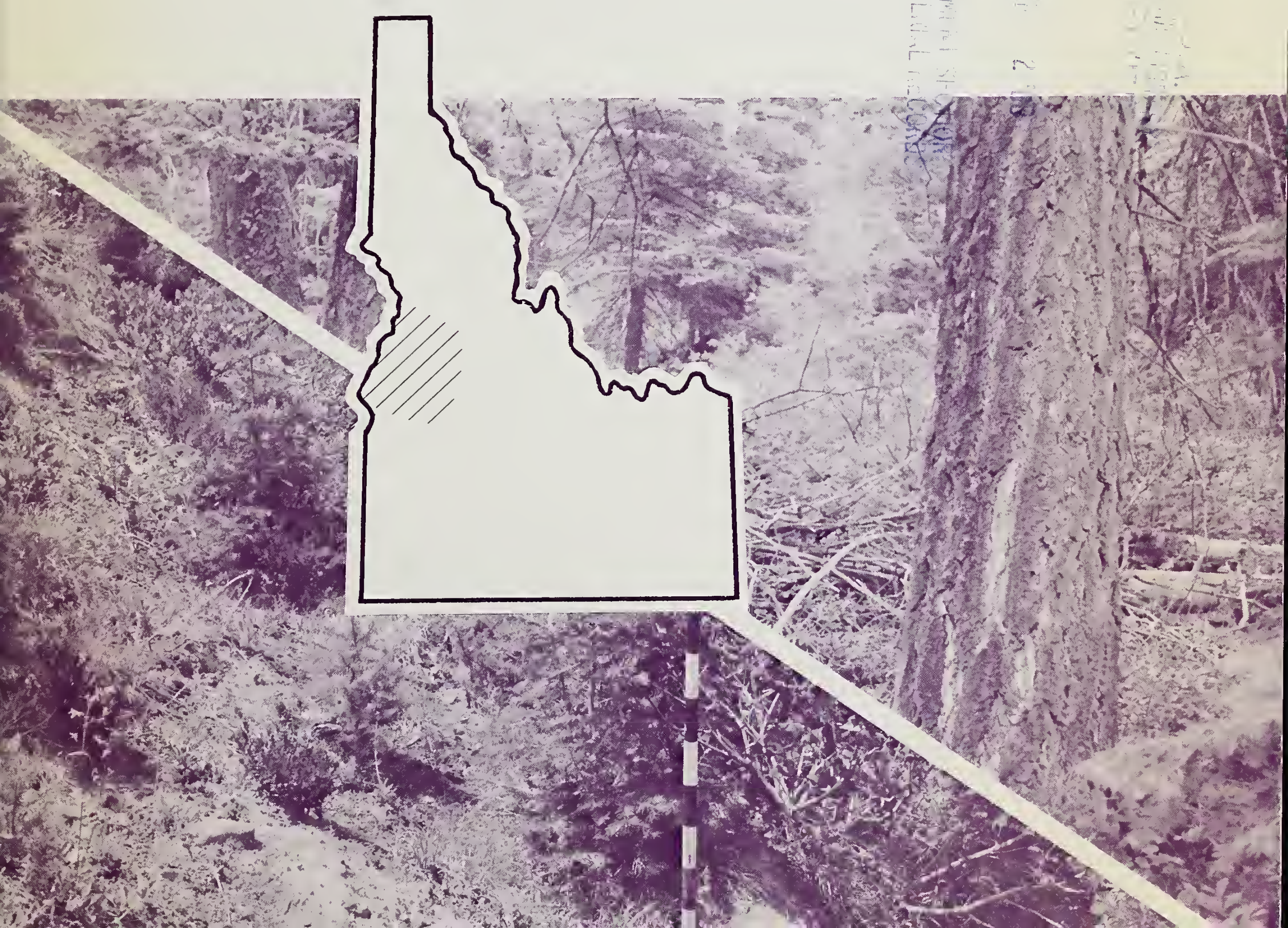

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RESEARCH SUMMARY

A system for classifying vegetational succession in the grand fir/blue huckleberry habitat type is presented. The system is based on reconnaissance sampling of 92 stands: 14 old-growth sites, 20 old-growth sites paired with disturbed sites, and 38 unpaired disturbed sites. A total of 21 potential tree layer types, 28 shrub layer types, and 36 herbaceous layer types are categorized by a hierarchical taxonomic classification. Diagnostic keys based on indicator species are provided for field identification of the layer types.

The management implications of various seral conditions are discussed. Implications include: occurrence of pocket gophers and success of tree plantations by site preparation treatments, initial growth rates of tree seedlings and yield capability of mature trees, microsite needs of natural tree seedlings, big-game and livestock forage preferences of shrub and herb layer types, and responses of major shrub and herb layer species to various disturbances. Species composition data for various types of tree, shrub, and herb layers are displayed in tables.

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INTRODUCTION

Over much of the West, development of habitat type classification based on potential natural vegetation (Pfister 1984) has fostered a growing awareness of vegetation and its variability. Those who manage natural resources now recognize the need to foresee impacts of their activities on the present vegetation and to understand possible changes that may result. But in order to understand all facets of vegetal change, one's perspective must encompass the often bewildering integration of cause and effect, and random, cyclic, and temporal relationships that are manifest in succession dynamics. Logically, the first step is to reduce this complexity to a manageable number of recognizable units in the form of a classification.

Habitat type classifications focus on the environmental (site) differences affecting vegetation. They provide a logical framework for studying succession and occasionally infer successional relationships but offer no classification of seral communities. As one approach to meeting this need, we present herein a classification of seral vegetation designed for general field use. In so doing, we have attempted to exploit the fact that natural classifications, in contrast to technical ones designed for a specific use, have broader application and often provide greater prediction capability. The widely accepted habitat type system of classification is an outstanding example of a natural classification and as its originators, R. and J. Daubenmire (1968), have pointed out "...that system may be considered the closest to a natural one that allows the most predictions about a unit from a mere knowledge of its position in the system." We developed the following classification with these criteria in mind so that the relative position of a classified unit in the system can help predict the successional direction of that unit. By doing this, we found that some types of seral vegetation are strongly related to a specific disturbance; other types develop mainly through uninterrupted succession. These cause and effect relationships are presented in various ways in the sections dealing with classification as well as those dealing with management implications.

Throughout this text the reader must remember that vegetation is influenced by time and environment. Environment, as it affects vegetation, can be delineated by habitat types or potential climax communities (Daubenmire 1952) that are relatively stable barring disturbance. In a similar manner, time, as it relates to succession, can be segmented by community types or seral stages that can be obliterated, slightly altered, or even advanced through various disturbances. Habitat type classifications have proven useful in much of the West (Layser 1974) and by focusing on climax potential enable investigators to hold time constant while grouping plant communities according to their environment. Conversely, environment can be held relatively constant by using habitat types while focusing on vegetal dynamics over time.

This report explores the changes in vegetation and related resource values occurring over time in one forest environment, the *Abies grandis/Vaccinium globulare* habitat type (ABGR/VAGL h.t.) (Steele and others 1981). The classification approach used here recognizes the individual nature of specific sites in terms of existing and potential species composition. It also recognizes that land managers need site-specific guidelines for intensive management purposes. In this regard, management implications for many species can be derived from each species' reaction to a particular disturbance and its successional strategy. This report can be applied to specific sites by understanding the successional characteristics presented for each major species and then synthesizing that knowledge for the existing and potential species on a particular site. Sometimes, the preliminary nature and meager data base herein require tentative use as a management guide. Throughout this report, users should focus on the relative nature of data presented rather than absolute values. This report is the result of 4 years of field sampling, preliminary drafts, and field testing. Suggested revisions and user feedback were analyzed and often adopted. These inputs have improved results of this report, but because this report was developed through a series of approximations, it should always be open to further refinement.

This report applies one concept for classifying seral vegetation (Steele 1984). It recognizes the somewhat independent nature of succession between the tree, shrub, and herbaceous layers (often due to layer-specific disturbances such as selective tree harvesting or grazing) and treats these three successions separately. It recognizes the high potential diversity of early and mid-seral vegetation and the relative forage values to livestock and big game. It also indicates some interrelationships of site treatment, planted tree survival, competing vegetation, and pocket gopher populations. Most important, it provides a common framework for communication among various disciplines.

Objectives

The objectives of this report are:

1. To develop a classification of seral community types in the ABGR/VAGL h.t. based on indicator species and vegetal structure.

2. To identify successional relationships of community types and relate these communities to the management treatments that gave rise to them.

3. To present species composition and canopy coverage information for each community type and the relative value of shrub and herbaceous community types as forage for big game and livestock.

4. To describe natural and artificial establishment and early growth characteristics of tree regeneration in relation to site treatment, microsite conditions, and competing vegetation.

5. To determine the number of years required for each tree species to reach breast height (4.5 feet, 1.4 m) in the ABGR/VAGL h.t.

6. To provide a basis for developing preliminary management implications by seral community type.

METHODS

Field Methods

Sampling methods followed those used previously in the central Idaho habitat type study (Steele and others 1981), with some modification. Thus sampling was done "subjectively but without preconceived bias" as described by Mueller-Dombois and Ellenberg (1974). Reconnaissance surveys were taken through areas known to have quantities of the grand fir/blue huckleberry habitat type as well as some disturbance from wildfire, timber harvest, and site preparation for tree planting. Potential sample sites were noted as to habitat type, kind and uniformity of disturbance, dominant vegetation, and approximate year of disturbance. Sample plots were selected to represent the range of site conditions and diversity of seral vegetation characteristic of the habitat type. In some cases, paired samples were selected from homogeneous sites that were partly in old-growth timber and partly in early seral condition. To the extent that time allowed, a large proportion of the available sites were sampled, with elimination of obviously duplicated situations in close proximity as well as sites where the treatment appeared to have been nonuniform.

Most seral stands that were sampled resulted from timber harvest. A few resulted from wildfire. The kinds of treatments sampled included: clearcut with no site preparation; clearcut and broadcast burned; clearcut, burned, and scarified; clearcut and scarified; and wildfire. Various grazing and browsing intensities by cattle, sheep, or big game also occurred on many of these sites. Circular sample plots nearly 1/10 acre (375 m^2) in size were located in representative portions of stands to reflect a certain treatment. Estimates of treatment age were obtained from all stands by various means, which included management records, evidence of tree growth release from increment cores, cross-sections of fire scars and machine scars on trees, and tree plantation signs. Plot centers were marked with a labeled wooden stake and referenced to roadside features to enable revisitation during the study. In all plots, the following observations were recorded.

Amounts of all vascular plant species were estimated by seven canopy-coverage classes (trace = 0-1 percent coverage, 1 = 1-5 percent, 2 = 5-25 percent, 3 = 25-50 percent, 4 = 50-75 percent, 5 = 75-95 percent, 6 = 95-100 percent). Species present in the stand but not in the plot were recorded as a "+". For maximum efficiency, these coverages were estimated within the entire 1/10-acre (375-m^2) macroplot (Pfister and Arno 1980) instead of using a series of small quadrats (Daubenmire 1959). The coverage class values were used directly in synthesis tables and ordinations. The canopy coverage for each tree species was subdivided into four diameter classes—less than 4 inches (10.2 cm), 4-12 inches (10.2-30.5 cm), 12-18 inches (30.5-45.7 cm), and over 18 inches (45.7 cm). Percentage of the surface covered with exposed mineral soil and rock was also estimated.

Trees more than 4.5 feet (1.4 cm) tall were tallied by 2-inch (5.1-cm) d.b.h. classes according to species. Trees between 4.5 (1.4 m) and 0.5 feet (0.15 m) tall were simply tallied by species. From 1979 to 1982, microsite conditions of trees older than 3 years and less than 4.5 feet (1.4 m) in height were recorded by species in a 538-ft^2 (50-m^2) circular plot. In 1983 the 538-ft^2 (50-m^2) plot was modified into five 108-ft^2 (10-m^2) circular plots so as to improve sampling accuracy. One 108-ft^2 (10-m^2) plot was placed at the macroplot center, two others were placed 18 feet (5.5 m) from each side of macroplot center along the contour, and the other two were placed 18 feet (5.5 m) from macroplot center perpendicular to the contour. All microsite conditions associated with tree seedlings were recorded in the 538-ft^2 (50-m^2) plot area. Observations were recorded regarding the association of each tree seedling with soil surface characteristics such as bare soil, litter, moss mats, or rotten wood and influential vegetation, or debris such as shrubs, grasses and forbs, rocks, or logs. Pocket gopher mounds made during the current year were also counted in the 538-ft^2 (50-m^2) area. If no mounds were found in the 538-ft^2 (50-m^2) area, the 4,037-ft^2 (375-m^2) macroplot was searched and the mounds were tallied accordingly.

Unidentified plants on each plot were collected and preserved for later identification or verification. A few plants in flower were also collected for voucher specimens. Many specimens collected during a previous study of the same area (Steele and others 1981) served as vouchers. Plant taxonomy follows Hitchcock and Cronquist (1973).

Observations were made on fire history, windthrow, snow damage to tree seedlings, insect and disease occurrence, grazing, use by wildlife, and distance from plot center to nearest mature conifer seed sources. Methods of logging, slash disposal, site preparation, and planting and seeding attempts were described and dated by various means: increment cores, fire scars, logging scars, land management records, or plantation signs.

When available, free-growing trees of each species present were measured for height and age in order to estimate site potential by species. Suitable site trees for each species were not always available, especially in the denser stands or in early seral stages. Free-growing shrubs were also measured for height when existing growth from sprouts or seedlings had been clearly initiated by a site treatment of known age.

Thicknesses of litter, fermentation, and humus layers were measured at three locations in the plot. Soil parent material, which is relatively uniform in the study area, was also identified when exposed by natural outcrops, road cuts, erosion, or logging disturbance.

From 1979 to 1981, plots in the grand fir/blue huckleberry habitat type were sampled when encountered during reconnaissance of other habitat types in central Idaho and a preliminary report was prepared (Steele and Geier-Hayes 1982). The summers of 1982 and 1983 were devoted to preliminary succession studies of Douglas-fir/ninebark and Douglas-fir/pinegrass habitat types (Steele and Geier-Hayes 1983, 1984). In the summer of 1984, sampling efforts again focused on grand fir/blue huckleberry and the adjacent grand fir/mountain maple habitat type (Steele and Geier-Hayes 1985), both of which occur mainly on the Boise and Payette National Forests. All of these sample data for grand fir/blue huckleberry plus data for mature stands from the habitat type classification study (Steele and others 1981) were used in this report.

Office Methods

After each field season, collected specimens of plants were identified. Occasionally some were sent to the University of Idaho herbarium for verification. Unknown vegetative material was compared with identified flowering specimens. All positive identifications were entered on the field forms and numerically coded for computer processing.

Prior to this overall study, little effort had been devoted to formulating an ecologic classification system for seral forest communities. Consequently, considerable time was spent during the first 2 years developing concepts and methods of classification technique. The resulting approach to classifying seral vegetation is presented in a separate paper (Steele 1984) that follows a cone model concept of succession (Huschle and Hironaka 1980). These concepts were applied to the ABGR/VAGL field data after the 1981 and 1984 field seasons in the following manner:

1. All available data for the ABGR/VAGL h.t., including habitat type classification data (Steele and others 1981), were examined to determine which species in the tree, shrub, and herb layers have potential to become well represented (>5 percent canopy coverage). From these data, three lists of indicator species were assembled, one for each vegetation layer, and the species were ranked subjectively according to their relative vulnerability to successional replacement (see figs. 2, 9, 19) as suggested by field observations, sample data, and available literature. (Relative vulnerability reflects the integrated effects of succession such as species longevity, shade tolerance, allelopathic and disease resistance, and reproduction strategy. Relative shade tolerance is often the apparent factor that determines vulnerability, but, as Minore (1979) suggests, other factors may be involved. Bazzaz (1979) addresses numerous physiological factors that affect relative vulnerability.) Species having similar successional roles and vulnerability, such as *Ribes viscosissimum* and *Ribes lacustre*, were lumped in order to simplify the lists.

2. From each list of indicator species a separate tentative classification diagram (see figs. 3, 10, 20) was generated. The most vulnerable indicator species forms the base of each diagram, with progressively less vulnerable species occurring upward toward the least vulnerable (climax) species. These indicator species are combined with all possible dominants of that particular vegetation layer. This series of possible combinations results in a triangular matrix. (See succession classification section for further explanation.)

3. A tentative key was constructed according to the structure of the classification diagrams (see tables 2, 7, 18), and the tree, shrub, and herb layer of each plot were then classified by layer type according to the appropriate key.

4. Stand data were assembled in synthesis tables (Mueller-Dombois and Ellenberg 1974) to show the early seral-to-climax arrangement of layer types (grouped stands) and layer groups (grouped layer types) resulting from step 3. These tables were studied in detail to ensure that declines and increases in key species followed logical successional patterns (derived from field observations) both within layer groups and between groups. Where illogical patterns appeared, individual stands in the synthesis tables were rearranged so that familiar seral species showed logical relative declines in canopy coverage and so the climax species showed stable or increasing coverages. Occasionally, the order of layer groups was changed to reflect the relative vulnerability of indicator species as suggested by the data.

5. For the shrub and herb layers, polar ordinations (Bray and Curtis 1957; Pfister and Arno 1980) were used to arrange the stands graphically on a quantitative basis of species composition and coverage. The ordinations were compared to the general pattern of stand groupings for that particular layer in the revised synthesis tables. Stands showing major discrepancies were considered for regrouping.

6. Following the previous adjustments, constancy and average cover values (from midpoints of coverage classes) were calculated for those species capable of achieving high constancies or high coverages. The classification diagram and key were adjusted to reflect the final stand groupings in each vegetation layer.

7. The resulting classification was field tested in subsequent field seasons but may need additional field testing for accuracy and completeness. New successional indicators may be encountered because the full environmental range of ABGR/VAGL may not have been sampled and the full successional range due to the many possible disturbances such as thinnings, insect attacks, and underburns may not have been sampled. If new indicators are found, they can be lumped with an ecologically similar indicator that already occurs in the classification diagram or the existing diagram can be expanded to accommodate the new indicator.

THE ABGR/VAGL HABITAT TYPE

Distribution and Description

The ABGR/VAGL h.t. occurs mainly in west-central Idaho (fig. 1) but extends into eastern Oregon (Johnson and Simon 1985). It is most common in drainages of the North Fork Payette and Weiser Rivers and occurs on both granitic and volcanic substrates. ABGR/VAGL is most commonly found between 5,200 and 6,200 feet (1,585 and 1,890 m) in elevation but can extend to as low as 4,500 feet (1,732 m) along cold air channels and upward to 6,500

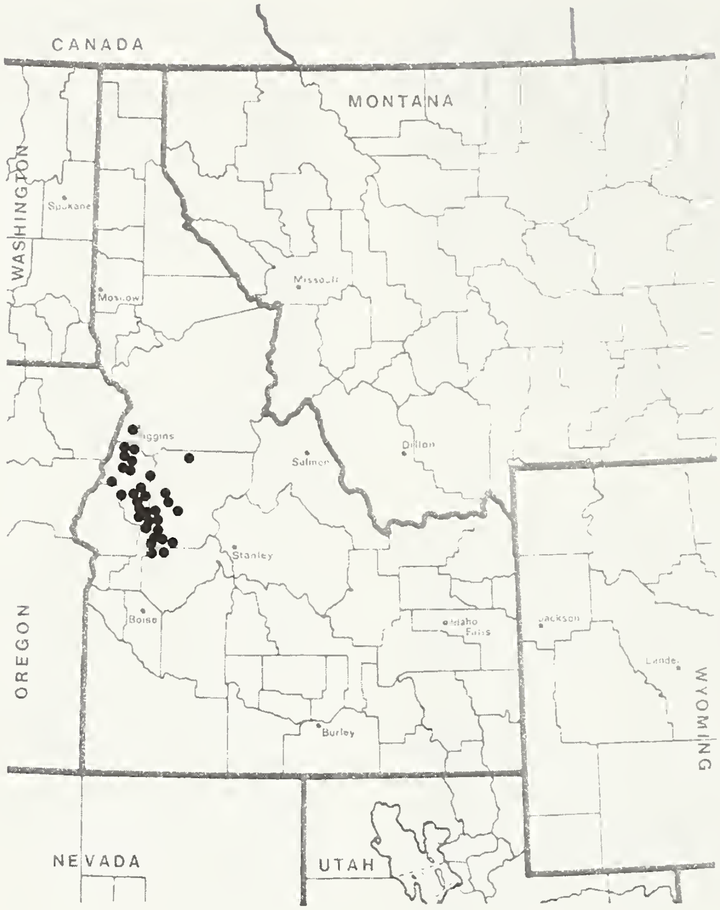

Figure 1—Distribution of ABGR/VAGL h.t. in Idaho.

feet (1,982 m) on slopes that shed cold air. Within this elevational range, the ABGR/VAGL h.t. reflects a relatively cool, moist environment that occurs mainly on northwesterly to northeasterly aspects. Adjacent cooler sites occur mostly in the subalpine fir series; adjacent warmer sites are usually grand fir/white spirea h.t.; adjacent warmer sites with more moisture are usually grand fir/mountain maple h.t. Although most sites in ABGR/VAGL support *Pseudotsuga* as a major seral species, other tree species may be more important where ABGR/VAGL approaches these other habitat types (table 1).

The early seral conditions found in ABGR/VAGL reflect most of the diversity of site history and site variability within the habitat type. For instance, *Pinus contorta* tends to colonize disturbed sites in frost pocket situations, whereas *Ceanothus velutinus* dominates severely burned areas that are not in frost pockets. *Carex rossii* and *Ribes*

Table 1—Successional role of tree species in ABGR/VAGL h.t. (revised from Steele and others 1981)

ADP No.	Tree species	Abbrev.	Role[1]	Occurrence
001	*Abies grandis*	ABGR	C	Occurs throughout
002	*Abies lasiocarpa*	ABLA	(c)	Cooler sites
007	*Picea engelmannii*	PIEN	(S)	Cooler, moist sites
016	*Pseudotsuga menziesii*	PSME	S	Occurs throughout
013	*Pinus ponderosa*	PIPO	(S)	Warmer sites
006	*Larix occidentalis*	LAOC	(S)	Moist sites
010	*Pinus contorta*	PICO	(S)	Cooler, frosty sites
014	*Populus tremuloides*	POTR	s	Occurs throughout

[1]C = major climax S = major seral
c = minor climax s = minor seral
( ) = occurs in part of the h.t.

viscosissimum tend to dominate scarified areas. *Ribes lacustre* appears mainly in the moister scarified areas that may eventually support *Alnus* and *Picea*. *Potentilla glandulosa* tends to dominate the drier scarified areas and sites that are repeatedly grazed. *Epilobium angustifolium* appears where the soil has been loosened and exposed. These disturbances and consequent vegetative reactions often appear in a mosaic on individual sites and present the field observer with a perplexing array of variability. These mosaics are best interpreted through repeated observations of larger, more uniform areas where the vegetation has reacted to a single identifiable site treatment.

In midseral conditions, tree composition is often diverse. *Pseudotsuga* is common throughout ABGR/VAGL. *Pinus ponderosa* is common in warmer portions of the habitat type and *P. contorta* can dominate in the colder portions, especially where cold air accumulates. *Picea* can dominate wetter portions of the habitat type, and *Larix* becomes increasingly prevalent northward in the ABGR/VAGL distribution. In the shrub layer, *Salix scouleriana* and *Spiraea betulifolia* often accompany the more shade-tolerant components, *Lonicera* and *Vaccinium*. *Alnus sinuata* may appear on the wetter sites that can support *Picea*. Herbs, too, are more numerous in midseral stages and often include *Castilleja, Fragaria*, and high coverages of *Arnica* or *Calamagrostis*.

In late seral-to-climax conditions, ABGR/VAGL supports nearly pure stands of *Abies grandis* or *Abies-Picea* mixtures; occasionally *A. lasiocarpa* is also present in response to the cool temperatures on these sites. In the undergrowth, *Vaccinium* achieves dominance through its rhizomatous habit, which enables it to outcompete its common nonrhizomatous associate, *Lonicera*. Species composition of the herb layer varies considerably but coverages tend to be low; *Thalictrum occidentale* or *Calamagrostis rubescens* usually dominates the herb layer.

SUCCESSIONAL FEATURES

Succession Classification

A systematic classification of seral vegetation within the ABGR/VAGL h.t. was developed as part of this study. The basic approach (Steele 1984) is to recognize the two primary factors affecting vegetal change: time and environment. Environmental variation has been categorized by the habitat type classification system (Steele and others 1981). The habitat type system uses indicator species according to their ability to dominate or at least maintain their population at climax. The relative value of a species as an indicator depends on that species' relative environmental amplitude, which is inversely related to indicator value.

Temporal variation within habitat types can be categorized by a similar system that uses indicator species according to their ability to dominate a seral stage. This system of classification depends on a species' relative successional amplitude (relative vulnerability to successional replacement) which is also inversely related to indicator value. Seral indicator species in a given habitat type can be arranged along the successional gradient according to their relative successional amplitudes. Figure 2 shows an example of this arrangement for the major tree species in ABGR/VAGL. These indicators are then combined with possible dominant species to provide a temporal-structural framework for classifying seral vegetation. Figure 3 shows the classification framework derived from figure 2. In contrast, if time is used on a yearly scale to classify seral communities, the relationship becomes untenable due to the randomness of successional forces such as seed crops, insects, disease, weather, and necessary combinations thereof.

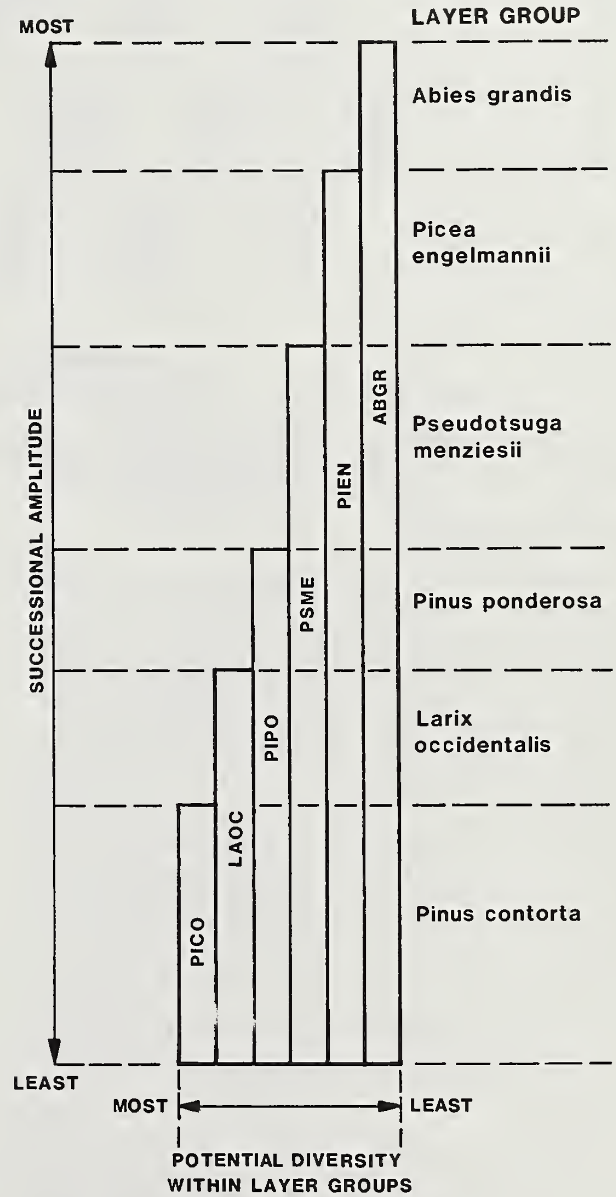

Figure 2—Relative successional amplitudes of major tree species in ABGR/VAGL h.t.

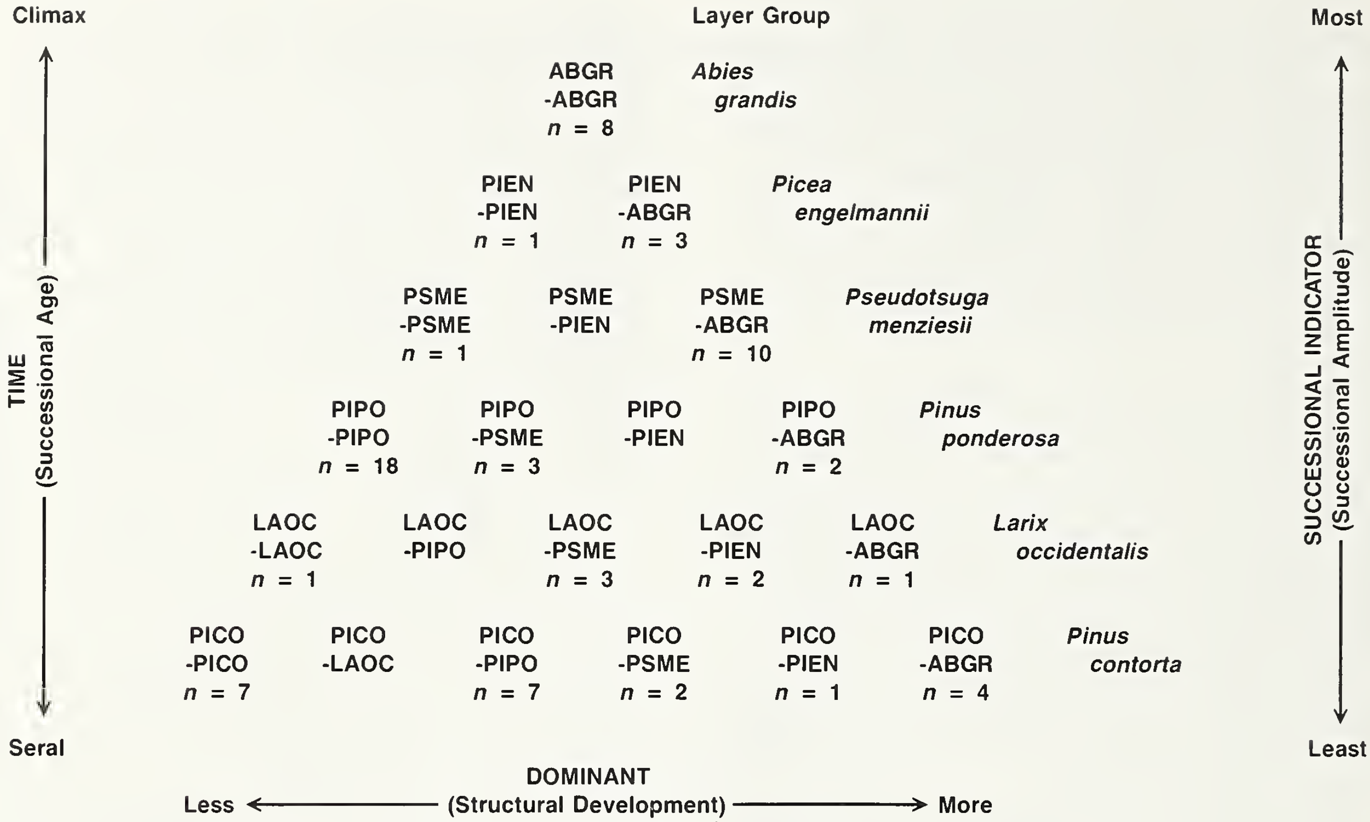

Figure 3—Example of succession classification framework using the tree layer in the ABGR/VAGL h.t. (n = number of samples in each layer type).

The Tree Layer

Because the tree, shrub, and herb layers follow partially independent successional patterns at different rates and may be affected by layer-specific disturbance, this classification focuses on the individual layers. The tree layer (trees over 4.5 feet [1.4 m] tall) in ABGR/VAGL contains six major species. Relative successional amplitudes of these species are shown in figure 2 with *Pinus contorta* having the least amplitude. Although *P. contorta* is more shade tolerant than *P. ponderosa* or *Larix* (Minore 1979), it has a shorter life span and achieves less height growth. Thus *P. contorta* is not likely to maintain itself beneath *Larix* or *P. ponderosa* unless some form of disturbance periodically creates a new seedbed for *P. contorta* and reduces the young *Pseudotsuga* or *Abies* that will accumulate in the understory. The relative amplitudes of *Larix* versus *P. ponderosa* are less clear, but the narrow crown and shorter life span of mature *Larix* would seem to favor *P. ponderosa* during succession. Likewise *P. ponderosa* is not apt to survive beneath the denser canopy of *Pseudotsuga*. Once the older pines in the stand have died, another successional segment is delineated. The passing of each of these species marks a segment in the successional sequence. *Abies grandis*, being the most shade tolerant, has the greatest successional amplitude and acts as the climax tree. Although various factors often preclude the entire replacement sequence, the relative successional amplitudes have been established for classification purposes.

Figure 2 suggests that possible diversity of the tree layer is greatest in the early seral stages. Here all six species could be present on the site, although usually this is not the case. In the climax stage, however, only *A. grandis* will be well represented, with all other tree species poorly represented or absent. Diminishing diversity during secondary succession becomes more apparent in the shrub and herb layer classifications where more species occur.

Figure 3 shows the various seral conditions in the tree layer that may converge to a common climax community of *A. grandis*. *Pinus contorta* forms the base of the triangle because it has the least successional amplitude. Other species are arranged in ascending order as a reflection of their progressively greater successional amplitudes. No single attribute, such as relative shade tolerance (Minore 1979) corresponds directly with all successional amplitudes because other factors may be involved and relative amplitudes reflect the integrated effects of all autecologic attributes influenced by succession.

In order to maintain a systematic taxonomic structure, each unit in figure 3 is called a layer type and each group of layer types having the same seral indicator is called a layer group. Layer groups denote the various seral stages that are possible within a given habitat type or phase. Layer types within one layer group such as PIPO-PIPO, PIPO-PSME, PIPO-PIEN, and PIPO-ABGR in the PIPO layer group (fig. 3) denote, in a general way, the structural conditions that are possible in that particular seral stage. These conditions may result from natural establish-

ment of tree seedlings or from tree plantations which often result in a given layer type (especially PIPO-PIPO). A layer type may vary structurally because more than two tree species may be codominant, although usually this is not the case. Potential variability within layer types is similar to the potential diversity within layer groups as shown in figure 2. Because this classification always uses the earliest seral species in terms of both the seral indicator and the dominant, one can assume that later seral or climax species may be present in the stand. Similar classifications were developed for the shrub and herb layers. If desired, taxonomy of the tree, shrub, and herb layers can be combined to characterize the entire plant community.

Delineating the vertical axis (time) into layer groups (fig. 3) provides an ecological basis for segmenting the successional time-sequence. As time progresses, a stand's classification status may progress from one layer group to a successionally older layer group. For instance, *P. ponderosa* (well represented) may dominate the tree layer (PIPO-PIPO) or may be dominated by *Pseudotsuga* (PIPO-PSME) or *A. grandis* (PIPO-ABGR). But the presence of *P. ponderosa* can always be interpreted as a specific segment of the succession sequence because the potential to be outcompeted by *Pseudotsuga* always exists. *Pinus ponderosa* is unable to replace *Pseudotsuga* without the aid of disturbance but can always outcompete *P. contorta.*

Figure 3 serves as a **classification diagram** (not a succession model) for seral tree layers in ABGR/VAGL h.t. These and the other diagrams herein do not outline actual succession sequences for a given site but rather illustrate the possibilities within the habitat type. Actual successions skip many layer types and even layer groups within their respective diagrams. A succession sequence can be described in terms of the layer types shown, but is determined by species composition of the stand and available seed sources.

Figure 3 also serves as a basis for constructing a simple key to tree layer types for field use. This is done by starting with the earliest layer group in figure 3 and progressing along the time gradient to climax (table 2). Keys to the shrub and herb layer types are constructed the same way. These keys are intended to be used in the same manner as the habitat type keys (Pfister and others 1977; Steele and others 1981).

Table 2—Key to tree layer groups and layer types, with ADP codes, in ABGR/VAGL h.t.

Key	Result	ADP codes
1. *Pinus contorta* well represented[1] (Choose first condition that fits)	PICO Layer Group	010
1a. *Pinus contorta* dominant	PICO-PICO Layer Type	010.010
1b. *Larix occidentalis* dominant or codominant	PICO-LAOC Layer Type	010.006
1c. *Pinus ponderosa* dominant or codominant	PICO-PIPO Layer Type	010.013
1d. *Pseudotsuga menziesii* dominant or codominant	PICO-PSME Layer Type	010.016
1e. *Picea engelmannii* dominant or codominant	PICO-PIEN Layer Type	010.007
1f. *Abies grandis* dominant or codominant	PICO-ABGR Layer Type	010.001
1. *P. contorta* poorly represented	2	
2. *Larix occidentalis* well represented (Choose first condition that fits)	LAOC Layer Group	006
2a. *Larix occidentalis* dominant	LAOC-LAOC Layer Type	006.006
2b. *Pinus ponderosa* dominant or codominant	LAOC-PIPO Layer Type	006.013
2c. *Pseudotsuga menziesii* dominant or codominant	LAOC-PSME Layer Type	006.016
2d. *Picea engelmannii* dominant or codominant	LAOC-PIEN Layer Type	006.007
2e. *Abies grandis* dominant or codominant	LAOC-ABGR Layer Type	006.001
2. *L. occidentalis* poorly represented	3	
3. *Pinus ponderosa* well represented (Choose first condition that fits)	PIPO Layer Group	013
3a. *Pinus ponderosa* dominant	PIPO-PIPO Layer Type	013.013
3b. *Pseudotsuga menziesii* dominant or codominant	PIPO-PSME Layer Type	013.016
3c. *Picea engelmannii* dominant or codominant	PIPO-PIEN Layer Type	013.007
3d. *Abies grandis* dominant or codominant	PIPO-ABGR Layer Type	013.001
3. *P. ponderosa* poorly represented	4	
4. *Pseudotsuga menziesii* well represented (Choose first condition that fits)	PSME Layer Group	016
4a. *Pseudotsuga menziesii* dominant	PSME-PSME Layer Type	016.016
4b. *Picea engelmannii* dominant or codominant	PSME-PIEN Layer Type	016.007
4c. *Abies grandis* dominant or codominant	PSME-ABGR Layer Type	016.001
4. *P. menziesii* poorly represented	5	
5. *Picea engelmannii* well represented (Choose first condition that fits)	PIEN Layer Group	007
5a. *Picea engelmannii* dominant	PIEN-PIEN Layer Type	007.007
5b. *Abies grandis* dominant or codominant	PIEN-ABGR Layer Type	007.001
5. *P. engelmannii* poorly represented	6	
6. *Abies grandis* well represented	ABGR Layer Group	001
6a. *Abies grandis* dominant	ABGR-ABGR Layer Type	001.001
6. *A. grandis* poorly represented	depauperate or undescribed tree layer or not ABGR/VAGL h.t.	

[1]"Well represented" means canopy coverage ≥5 percent regardless of diameter classes of the trees involved. Trees less than 4.5 feet (1.4 m) tall should be omitted from coverage estimates. "Dominant" refers to greatest canopy coverage, "codominant" refers to nearly equal canopy coverage. When keying to layer type, choose first condition that fits.

SIZE CLASS NOTATIONS

The basic classification approach used in the tree, shrub, and herb layers is presented in figures 2 and 3 and table 2, but because the tree layer progresses through recognizable size classes of development such as sapling (0.1-4 inches, 0.25-10.2 cm d.b.h.), pole (4-12 inches, 10.2-30.5 cm), mature (12-18 inches, 30.5-45.7 cm), and old-growth (>18 inches, 45.7 cm), these additional subdivisions should be noted. These notations are best added to each tree species after the tree layer type (l.t.) is identified, such as, mature PIPO-sapling PSME l.t. For consistency, the smallest size class that is well represented should be noted for the successional indicator because it usually reflects the most recent regeneration of that particular species. For the dominant species, the dominant size class should be used. When the indicator species is well represented in the stand but not in any one size class or the dominant species does not have a dominant size class, the size class with the most coverage should be noted. For convenience, size class notations can be abbreviated as follows: s. - sapling; p. - pole; m. - mature; and o.g. - old-growth.

It may be difficult, at first, to visualize some tree layer types in their appropriate successional position. For instance, an s. ABGR - s. ABGR l.t. may not seem to be successionally older than an m. PICO - s. PSME l.t., because we normally think of time-related situations on a yearly scale. On a successional scale, however, a pure stand of sapling *A. grandis* is closer to climax than a mixed older stand of *P. contorta* and *Pseudotsuga* because it will not go through the earlier successional stages of the PICO and PIPO layer groups. In fact, an s. ABGR - s. ABGR l.t. may even reach climax in fewer years because no species replacement (succession) is needed, whereas an m. PICO - s. PSME l.t. must first lose the *P. contorta* and if *Larix* or *P. ponderosa* is well represented must also pass through a LAOC-PSME or PIPO-PSME l.t. as well as a PSME-ABGR l.t. before reaching climax.

The six possible tree layer groups in ABGR/VAGL (fig. 3) are described below and delineate tree layer succession into relatively broad segments. Because layer groups are usually delineated by a single indicator species, their origin can be related to a somewhat consistent set of site conditions. But progression from one layer group to another (and one layer type to another) depends on composition of the individual stand and, therefore, is predictable only from field observation. The following layer group descriptions are presented in the order they appear in the key (table 2). Constancy and average coverage of species within sampled layer types appear in appendix A.

PINUS CONTORTA LAYER GROUP (PICO L.G.)

Pinus contorta occurs frequently in ABGR/VAGL, but becomes most abundant in cooler portions of the habitat type. Where *P. contorta* is a dominant species, it generally indicates a frost pocket condition and is usually the tree species most capable of regenerating the site. In some cases the pattern of clearcuts in the area has increased the frost pocket effect, leaving *P. contorta* to dominate sites where other species were once able to establish (fig. 4). Historically, severe wildfires were the cause of the PICO l.g., but more recently, clearcuts with burning or scarification have produced a similar result.

In ABGR/VAGL, PICO layer types represent the earliest seral stages of the tree layer and are often found as sapling or pole-size stands (fig. 5). The relatively short-lived nature of *P. contorta* allows this layer group to be replaced in a relatively short time. Most sampled stands in the PICO l.g. will progress directly to the PSME, PIEN, or ABGR l.g.; a few will progress to the PIPO l.g. Progression to the LAOC l.g. appears to be rare.

LARIX OCCIDENTALIS LAYER GROUP (LAOC L.G.)

Larix occidentalis occurs sporadically in the ABGR/VAGL h.t. and is usually most abundant on the moister sites that support *Picea*, *Alnus*, and *Ribes lacustre*. In central Idaho, *Larix* extends its range southward primarily in the ABGR/VAGL h.t. Its southern limit as an important timber species occurs near Smith's Ferry, ID. Occasional trees occur southward to Garden Mountain northeast of Banks, ID (Bruna 1984). Although old-growth *Larix* are often present in older stands in ABGR/VAGL, *Larix* was seldom found as a major component of naturally established sapling or young pole-size stands. Reasons for the sparse establishment of *Larix* are not clear but may relate to the fact that *Larix* is near its southern limits in ABGR/VAGL. Historically, the LAOC l.g. reflects severe disturbance from wildfire. Yet clearcuts with broadcast-burn or scarification treatments have resulted in only small amounts of *Larix* regeneration. Reduction of seed sources through timber harvest and possibly a marginal environment for natural establishment of *Larix* seedlings may be responsible for lack of *Larix* in clearcuts. With the older stands being rapidly harvested and fire control becoming increasingly effective, the southernmost populations, and possibly ecotypes, of *Larix* could become extirpated. Yet on some sites, planting *Larix* in a mixture with other tree species would enhance stand structure and diversity.

The LAOC l.g. is relatively rare in ABGR/VAGL. Of the seven stands encountered, four are apparently progressing toward the PSME l.g., one toward the PIPO l.g., and one toward the PIEN l.g. The seventh stand was a young *Larix* plantation with no successional sequence yet apparent.

PINUS PONDEROSA LAYER GROUP (PIPO L.G.)

Pinus ponderosa is a major seral tree of ABGR/VAGL but does not always establish readily following disturbance. Lack of seed and unsuitable seedbeds often limit pine regeneration. Distance to seed source, poor dispersion of the heavy seed, and infrequent seed crops appear mainly responsible for lack of seed in large clearcuts. *Carex geyeri*, *Calamagrostis*, and several shrubs are stimulated by burning or logging and can quickly dominate potential seedbeds. As a result, natural establishment of *P. ponderosa* is often slow and sporadic, but well-scarified sites beneath a light canopy of seed-producing pine should regenerate a PIPO layer type provided the site is not moist enough to support *Alnus sinuata*. A high density of

Figure 4—A sapling PICO - sapling PICO tree layer type southeast of Smith's Ferry, ID. This site was clearcut and broadcast burned 15 years ago. It was planted unsuccessfully to *Pseudotsuga* the following year. The pattern of clearcuts in this area increased the frost pocket effect and likely enhanced the opportunity for *Pinus contorta* establishment. *Pinus contorta* colonized the site from a nearby seed source and is now the dominant tree.

Figure 5—A dense pole PICO - pole PIEN tree layer type northwest of New Meadows, ID. The many fallen stems of *Pinus contorta* suggest that the pine once dominated this site. *Pinus contorta* is still well represented, but the more shade tolerant *Picea engelmannii* is now the dominant tree. No other tree species is well represented. As the pine continues to decline, this stand will progress to a PIEN-PIEN tree layer type.

Picea or *Ribes lacustre* or the presence of *Actaea* or *Alnus* are likely indicators of potential alder sites. The alder colonizes bare soil from windblown seed and may outcompete the pine seedlings. Although occasional pines may be present on these alder sites, attempts to establish stands of pine naturally, and possibly by planting, may not succeed.

The PIPO l.g. occurs in much of the ABGR/VAGL h.t. except in frost pockets and other relatively cool sites. Naturally established sapling to pole-size stands in the PIPO l.g. are rare; most are plantations (fig. 6). Scattered mature to old-growth trees are common and reflect a history of fire but stands dominated by older *P. ponderosa* are scarce. Because *P. ponderosa* is relatively long-lived, this layer group is one of the more persistent seral conditions in ABGR/VAGL. Most of the sampled stands appear to be progressing toward the PSME l.g.

PSEUDOTSUGA MENZIESII LAYER GROUP (PSME L.G.)

Pseudotsuga is the most common seral tree in ABGR/VAGL, yet it rarely dominates following clearcutting. Plantings of *Pseudotsuga* have been tried in ABGR/VAGL but few have succeeded. Causes of failure are not well documented, yet many sites in ABGR/VAGL appear suitable for *Pseudotsuga* plantations. Established *Pseudotsuga* seedlings often appear to have benefited from a protected seedling microsite. Rocks, logs, and shrub and tree canopies all provide microsite protection. Most natural stands of *Pseudotsuga* apparently established under the shelter of trees or shrubs.

Stumps and fallen logs suggest that all sampled stands in the PSME l.g. progressed from the PICO, LAOC, or PIPO layer groups. Three of these stands will likely become a PIEN l.t.; the remainder are progressing directly to ABGR-ABGR. In several stands, selective cutting of the pines and larch has accelerated succession into the PSME l.g.

PICEA ENGELMANNII LAYER GROUP (PIEN L.G.)

Picea engelmannii is considered relatively shade tolerant and a late seral to near climax species in ABGR/VAGL. Although *Picea* may appear throughout much of the habitat type, its best development occurs at the moist extreme where *Alnus, Ribes lacustre,* or *Actaea rubra* are

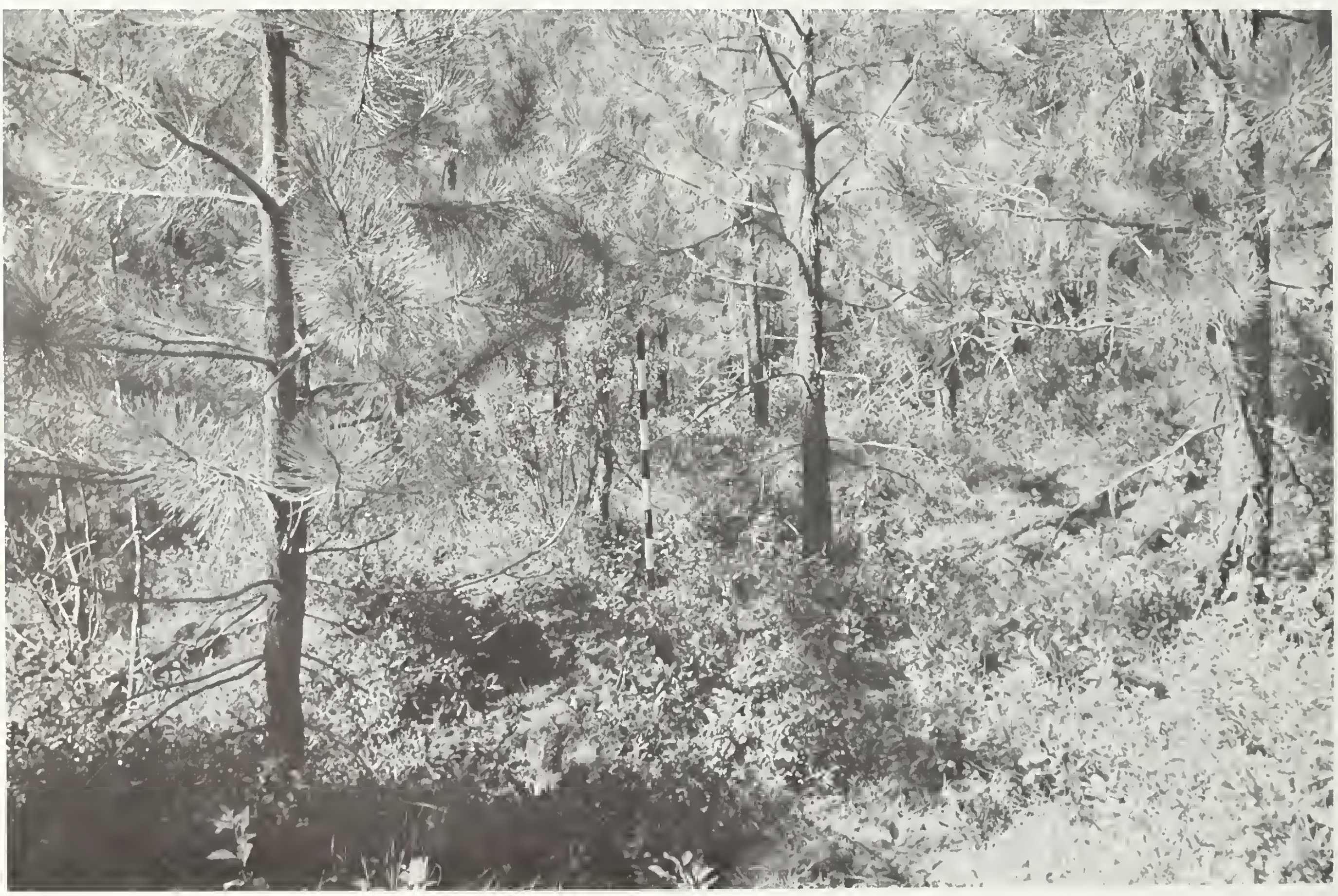

Figure 6—A well-stocked sapling PIPO - sapling PIPO tree layer type east of Cascade, ID. This area was clearcut and well scarified 19 years ago. It was successfully planted to *Pinus ponderosa* the following year. Now the pine clearly dominates the site. Trace amounts of *Pinus contorta*, *Pseudotsuga*, and *Abies grandis* have established naturally.

evident. The litter and duff from *Picea* inhibit germination and growth of certain conifers, particularly *Picea, Pseudotsuga*, and *Pinus contorta*. One study (Daniel and Schmidt 1971) suggests that fungi living in the duff inhibit seedlings of these tree species while another study (Taylor and Shaw 1982) implicates allelopathic chemicals (tannins and stilbenes) as the inhibitory agent. Whatever the cause, a mineral-soil seedbed is clearly essential for achieving adequate regeneration of *Picea, Pseudotsuga*, and *P. contorta* wherever large *Picea* now stand.

The PIEN l.g. contains two layer types, both of which were sampled (fig. 3). All of these samples were mature to old-growth stands, reflecting the long fire-free interval needed for spruce development. Successionally, these stands tend to be quite persistent but eventually progress to the ABGR l.g.

ABIES GRANDIS LAYER GROUP (ABGR L.G.)

Abies grandis is the most shade-tolerant tree that can dominate in the ABGR/VAGL h.t. and hence acts as the climax indicator. As a result, the ABGR l.g. often occurs as a mature or old-growth stand under natural conditions (fig. 7). Selective logging or clearcutting with no site preparation, however, can produce the ABGR l.g. in sapling or pole stages. Such results may leave little opportunity for the seral, and more commercially desirable, trees to establish. Although logging has converted an old-growth stand to saplings or poles, actual succession of the tree layer may have been accelerated to the ABGR l.g. In these situations, additional site treatment will be needed to obtain more commercially desirable tree species. Seral species may also be more ecologically desirable in terms of maintaining a healthy and more fire-resistant stand. Compared to other tree layer types in ABGR/VAGL, ABGR-ABGR l.t. has the greatest hazard potential for catastrophic fire, insects (spruce budworm), and disease (heart rot). If all fire, insect, and disease hazards, including decay, could be measured on a common scale between habitat types, maximum hazard potentials in climax tree layer types may be axiomatic.

MANAGEMENT IMPLICATIONS

The following implications for management of the tree layer were derived from data and repeated field observations taken during this study and the habitat type study (Steele and others 1981). Users of the following information should keep in mind the often small sample size of the

Figure 7—A pole ABGR - mature ABGR tree layer type in the Lost Creek drainage west of New Meadows, ID. This nearly pure stand is dominated by mature *Abies grandis* with pole-size *Abies* well represented. Scattered dead standing and fallen stems of *Pinus contorta* suggest a previous tree layer composition of PICO-ABGR.

data set and the minimal amount of field testing and user response. Yet trends reflected by these data appear logical and seem adequate to support interpretations on a relative basis.

Pocket Gophers—It has long been known that pocket gophers (*Thomomys talpoides*) can damage pine plantations (Moore 1943; Dingle 1956). Reasons for this damage have been studied at length. In summarizing gopher-related studies, Teipner and others (1983) suggest that gopher damage to young pines may be related to amount and composition of associated plant species as well as gopher density. Our studies indicate that species composition can vary with type of site preparation prior to tree planting which, in turn, may influence gopher populations. Therefore pocket gopher mounds were tallied (Richens 1965) in our sample plots and then summarized by site treatment.

Most sites in ABGR/VAGL had few or no gopher mounds, but a notable increase in gopher mound occurrence was found on sites that had been scarified without burning. About 20 percent of the partially cut stands and 33 percent of the clearcuts that had been scarified without burning had gopher activity, whereas all other site conditions had virtually none (table 3). Gopher activity is also more evident on unburned scarified sites in several other habitat types (Steele and Geier-Hayes 1984, 1985, 1986).

Table 3—Occurrence of pocket gopher mounds following various site disturbances in ABGR/VAGL h.t.

Site treatment	Number of sites	Mound occurrence[1]
Clearcut, broadcast burned, or stand destroyed by wildfire	4	0(0) - 0(24)
Clearcut, broadcast burned, and scarified	4	0(0) - 0(12)
Clearcut and contour terraced	5	0(0) - 0(14)
Clearcut, unburned, and scarified	30	33(284) - 12(12)
Partial cut and scarified	5	20(225) - 22(21)
Clearcut and no site preparation	4	0(0) - 0(10)
Uncut stands, no site preparation	18	5(30) - 53(74)

[1]Expressed as: percentage constancy (average number/acre) - average years since disturbance of sites with mounds (of sites without mounds).

The gophers, of course, do not respond directly to the site treatment but rather to the vegetation resulting from the treatment. Scarification, either by machines or heavy livestock use, is most apt to generate early seral herbaceous layers which likely stimulate gopher populations. In contrast, burning without scarification often results in a dense shrub layer and thus a depauperate herb layer. Burning may also result in herb layers that are less appealing to gophers. (See herb layer section for further discussion.)

Planted Tree Establishment—Planted sites were identified from plantation signs and obvious rows of even-aged trees. Seedling survival was estimated in percentage and recorded for each site preparation technique. Site preparation included no preparation, hand scalps, scarification with and without burning, and contour terraces. Hand scalping was grouped with no preparation because it usually did not reduce long-term competition and because it could not always be recognized in older plantations. Scarification treatments usually resulted from stripping, pile and burn operations, or extensive machinery traffic during the logging. Sometimes broadcast burns were also applied following the logging operation. Scarification treatments are uncommon, however, on many of the steeper slopes associated with this habitat type. Contour terraces varied in width from 2 to 3 feet on gentle terrain to 6 to 8 feet on the steeper slopes. The wider terraces were more widely spaced on the slope so as to reduce erosion. Contour ditches appear to have the same effect on tree growth and survival as contour terraces and so were grouped with that treatment.

Survival of planted *Pinus ponderosa* (table 4) was greatest (about 82 percent after 16 years) on contour terraces and about equally successful (79 percent after 9 years) on

Table 4—Success of tree plantations by site treatment in ABGR/VAGL h.t.

Tree species	Site treatment[1]: None includes hand scalps	Broadcast burning	Scarified unburned, includes stripping	Contour terraces, includes ditching
	Survival of plantings, percent (average age)[2]			
PICO	—	—	99(14) n = 1	80(19) n = 1
LAOC	—	—	?(10) n = 1	—
PIPO	30(14) n = 1	65(18) n = 1	79(9) n = 6	82(16) n = 6
PSME	—	1(13) n = 1	23(10) n = 6	50(6) n = 2
PIEN	—	—	—	80(11) n = 1
	Average age to breast height, years			
Planted[3]				
PICO	—	—	9 n = 1	9 n = 1
LAOC	—	—	6 n = 1	—
PIPO	—	10 n = 1	8 n = 18	7 n = 6
PSME	—	—	9 n = 8	—
PIEN	—	—	10 n = 1	11 n = 1
Natural				
PICO	—	6 n = 3	8 n = 7	8 n = 4
LAOC	—	—	7 n = 4	—
PIPO	—	9 n = 1	9 n = 2	—
PSME	—	—	—	14 n = 1
ABGR	—	—	12 n = 3	20 n = 1

[1]*n* = number of sample sites.
[2]Plantings less than 4 years old were omitted; complete plantation failures and multispecies planting could not be sampled for survival.
[3]Nursery years are not included.

sites that had been scarified but not burned. These treatments minimize potential shrub competition for many years by removing seed and some root crowns from the site, whereas burning encourages certain shrubs to germinate from buried seed or resprout from existing root systems. Broadcast burning results in a dense shrub cover relatively quickly and in a few years creates situations for which *Pseudotsuga* is better adapted than *P. ponderosa*. The *Pseudotsuga*, being more shade tolerant than pine, is not as adversely affected by shrub development in later years. In early years, the shrub canopy may even provide critical protection for *Pseudotsuga* seedlings.

The survival percentages in table 4 may differ considerably from Ranger District records for two reasons. First, the data reflect planting attempts over many years and many early planting failures were due to factors other than site treatment and habitat type. Second, the data reflect plantation success over the past 10 to 20 years, whereas District records are generally maintained for only a few years after planting and do not always reflect the full effects of the site and long-term competition. Our figures are not necessarily the highest possible survival rates because occasionally high survival has been achieved in most treatment categories. Our survival rates are best interpreted as relative probability of success rather than percentage of survival.

Age to Breast Height—The years required for a tree to reach breast height (4.5 feet, 1.4 m) is a critical factor in estimating growth and yield parameters of forest stands as well as seedling success against competing vegetation. Normally an estimated constant is used for a given species regardless of site. Yet for some species, sample data have shown considerable variability in breast height ages between habitat types and even between site treatments within a habitat type. In ABGR/VAGL, breast height age for planted *Pinus ponderosa* is about 7 to 8 years regardless of site treatment (table 4). In the drier Douglas-fir/ninebark and Douglas-fir/pinegrass habitat types, age to breast height of pine could be reduced 2 to 3 years by planting on contour terraces (Steele and Geier-Hayes 1983, 1984). This does not appear to be the case in the wetter grand fir/mountain maple (Steele and Geier-Hayes 1985) or ABGR/VAGL h.t.'s, which suggests that terraces improve the moisture regime for pine on drier sites but may have little benefit on sites with adequate moisture.

Snow Damage to Pine Plantations—Extensive snowpack damage to ponderosa pine plantations was previously noted in the grand fir/mountain maple habitat type (Steele and Geier-Hayes 1985) and led to an assessment of similar damage in ABGR/VAGL. The damage is sustained mainly by trees greater than 4 to 5 feet (1.2 to 1.5 m) tall. It varies from stripped lateral branches and bent terminals to permanent 90-degree angles in the main stem and entire saplings pushed into semiflattened positions. Stem internodes indicate that, once damaged, the pine's growth rate is reduced for a year or more, making the young tree more vulnerable to shrub competition (fig. 8). With *Pinus contorta*, Rehfeldt (1987) noted a similar loss in growth rate of 22 percent. Long-term snow records suggest that subsequent damage may occur about every 4 years, causing accumulated deformities. In spring, these bent, stunted trees remain beneath the snow longer than undamaged trees and during prolonged snowmelt can suffer increased mortality from the brown-felt blight (*Neopeckia coulteri*).

Most pine plantations situated below 5,500 feet (1,676 m) in elevation escape serious snow damage regardless of aspect or slope. Nevertheless, the main stems and side branches may be temporarily deformed, particularly on westerly aspects. As elevation increases from 5,500 to about 5,800 feet (1,676 to 1,768 m), damage potential also increases. But damage may be less severe on north aspects (between 340 and 20 degrees) or under certain site conditions described below. Slope steepness is a relatively minor variable because most slopes in ABGR/VAGL are steep enough to cause snow movement. Above 5,800 feet (1,768 m) snow damage is apt to occur on any aspect but can be alleviated by certain conditions. For instance, pine plantations near ridgetops may escape snow damage within the hazard zone outlined above. Likewise, plantations that are well shaded in early spring by a nearby ridge or adjacent old-growth stand may escape damage. Damage-free plantations were found as high as 5,900 feet (1,798 m) regardless of aspect under these circumstances. Sites with high stumps and large logs or boulders can also reduce snow hazards. Proper location and treatment of cutting units can exploit these advantages where high damage potential exists. Where the risk cannot be alleviated, plantings of *Pseudotsuga* and *Larix*, although they may have lower survival than pine initially, can sustain greater snow-bending and may prove more successful than pine over the long term.

In contrast, potential snow damage can be increased to as low as 4,300 feet (1,311 m) by contour terraces. In steep terrain, these terraces are often quite wide and accumulate more snow than adjacent slopes. Terrace cutbanks create a steepened sliding surface that exacerbates snow movement. The pines planted closest to the cutbank are most apt to be damaged while those nearest the fill slope often escape damage.

Extent of snow damage within plantations can vary from scattered individual trees at lower elevations to virtually all trees at the upper elevations. Trees having only light damage (bent terminals) generally recover as described by Oliver (1970) unless repeatedly damaged. Severely damaged trees probably could recover but are usually situated so as to receive repeated snow damage, making full recovery unlikely.

Proper genetic seed source is a critical factor in snow damage susceptibility and recovery (Rehfeldt and Cox 1975). In general, plantations from lower elevation seed sources are not apt to grow successfully in the snow hazard zone, whereas trees from appropriate seed sources tend to sustain less damage and recover more readily. At upper elevations of the snow hazard zone, however, even pine plantations of the proper seed source may experience reduced stocking levels and lower growth rates. Recognizing snow damage potential may be difficult in some situations, but it is an important consideration when planting *Pinus ponderosa* on ABGR/VAGL sites above 5,500 feet (1,676 m) in elevation. For a more detailed approach to predicting snow damage hazards in pine plantations see Megahan and Steele (1987).

Figure 8—A badly snow-damaged plantation of *Pinus ponderosa* in the Squaw Creek drainage north of Ola, ID. These stunted, deformed trees appear to have sustained repeated damage. Loss of height growth has jeopardized these pines' ability to outcompete the dense shrub layer.

Growth and Yield Capability—Height-age data of free-growing trees, usually in clearcuts or burns, were collected during the course of this study. These data provided growth information for the younger age classes of major tree species in ABGR/VAGL. Similar data in older age classes were taken from dominant or codominant trees in old-growth stands during this study and the habitat type classification study (Steele and others 1981). Increment cores of these older trees were examined for evidence of suppression. If the core indicated past suppression or if it was too far from the pith to allow a confident estimate of total age, the tree was rejected. Remaining data were used to estimate site index and yield capability.

Sources for estimating site index and yield capability for the various species are shown in table 5. The *Abies grandis* site index and yield capabilities were derived from Stage (1959) and Brickell (1970), respectively. But, the values were read directly from graphs rather than using equations that require crown ratios, an unavailable input. The *Picea* site index was converted to a 50-year base from Alexander's (1967) *Picea engelmannii* curves; related yield data provided by Alexander (Alexander and others 1975) enabled us to compute spruce yield capability for natural stands as outlined in Steele and others (1981). The *Pseudotsuga* site index was plotted from Monserud's (1985) site curves for *Pseudotsuga* in the *Abies grandis* series, but because no yield tables exist for *Pseudotsuga*, Brickell's (1970) *Pinus ponderosa* yield curve was used. The *Pinus ponderosa* site index and yield capability were derived from Brickell's (1970) site curves which are a conversion to a 50-year base age from Lynch (1958). Site index and yield capability for *Larix* and *Pinus contorta* were derived from Brickell (1970).

The growth and yield capabilities of major tree species in ABGR/VAGL are shown in table 6. *Picea* and *Pinus ponderosa* show about the same yield capability, but these species seldom grow equally well on the same site. *Picea* grows best on the cooler or moister sites that also support *Pinus contorta, Alnus sinuata,* or *Ribes lacustre. Pinus ponderosa* shows its best growth on the warmer, better drained sites that lack these species. In old-growth stands of ABGR/VAGL, remnants of the pine or spruce may provide the best clue as to which species is best suited for a particular site. It should be remembered, however, that *P. ponderosa* seldom dominates these sites naturally, and old trees may exist only sporadically on sites having high potential for this species. Also *P. contorta* may easily invade sites having a high potential for *Picea,* but as table 6

Table 5—Sources for estimating site index and yield capability

Species	Years to breast height[1]	Source of site curve[2]	Source of yield capability
Abies grandis	—	Stage 1959	Brickell 1970
Picea engelmannii	—	Alexander 1967	Alexander[3]
Pseudotsuga menziesii	9	Monserud 1985	Used PIPO curve
Pinus ponderosa	8	Lynch 1958	Brickell 1970
Larix occidentalis	7	Brickell 1970	Brickell 1970
Pinus contorta	8	Brickell 1970	Brickell 1970

[1]Where no value is shown, curves based on age at breast height were used.
[2]Site curves with a 100-year index age were converted to a 50-year index age.
[3]Based on data provided by Alexander from Alexander and others (1975) from which a linear regression of yield capability for natural stands was developed (Steele and others 1981). (Yield capability = −26.0 + 1.84 × 50-year site index, R^2 = 0.66.)

shows, some yield capability can be lost by allowing *P. contorta* to dominate these sites. Because *P. contorta* approaches its warm limits in ABGR/VAGL, even well-managed stands of this species may produce less volume than moderately managed stands of the other tree species. Table 6 shows *Abies grandis* as having the highest yield capability, but in ABGR/VAGL the heartwood of *A. grandis* is often infected with Indian paint fungus (*Echinodontium tinctorum*), which markedly reduces merchantable volume.

Table 6—Growth and yield characteristics of trees in ABGR/VAGL h.t.

Tree species	Number of site trees	Site index (50-year base)	Number of stands	Yield capability
				Ft³/acre/year
Abies grandis	12	52 ± 6[1]	12	111 ± 11
Picea engelmannii	8	66 ± 5	8	96 ± 9
Pseudotsuga menziesii	16	61 ± 5	16	82 ± 9
Pinus ponderosa	20	67 ± 4	19	97 ± 12
Larix occidentalis	7	65 ± 7	7	85 ± 16
Pinus contorta	9	59 ± 3	7	73 ± 6

[1]95 percent confidence intervals.

SUMMARY OF TREE LAYER SECTION

In ABGR/VAGL, *Pinus contorta* is considered the least tolerant of succession followed by *Larix, Pinus ponderosa, Pseudotsuga, Picea,* and finally *Abies grandis. Pinus contorta* will dominate mainly in frost pocket areas; *Picea* will dominate mainly on the wetter sites that support *Actaea, Alnus,* or *Ribes lacustre.* Sometimes these wetter sites are also frost pockets. *Larix* approaches its southern limits in ABGR/VAGL and does not always reestablish readily in suitable seedbeds. *Pinus ponderosa* seldom colonizes large clearcuts due to poor seed dispersal, cyclic cone crops, and rapidly developing shrub competition. *Pseudotsuga* establishes best where the seedling microsite is protected from wind and intense sunlight.

Clearcutting followed by scarification without burning, such as dozer-piling operations, minimizes long-term shrub competition for tree seedlings and results in high survival of planted *P. ponderosa* and *P. contorta.* Unfortunately, this site treatment is the one most apt to increase pocket gopher activity and provide minimal wildlife forage. Contour terracing or ditching also results in high survival of planted pines but may increase *Salix* establishment as well as snow damage hazards to pine plantations.

Clearcutting followed by broadcast burning results in less gopher activity and greater wildlife forage but allows tall-growing shrub species, such as *Salix,* to resprout and suppress planted pines. In contrast to scarification, the shrub layers that result from burning are usually too dense to allow replanting of the site if the first tree planting should fail.

Clearcutting with no site preparation can minimize gopher activity and generate forage for wildlife but provides little opportunity for establishment of pine or larch.

Partial cutting followed by scarification can be used to establish *P. ponderosa, Pseudotsuga,* or *Picea* provided the desired seed source exists in the overstory. When a minimal overstory remains, as in a shelterwood for pine, pocket gopher activity may increase.

Potential snow damage to pine plantations increases with elevation starting at about 5,500 feet (1,676 m), especially on westerly aspects. Extent and severity of damage can be reduced by using the proper seed source and leaving high stumps, logs, and boulders on the site. Contour terraces can increase snow hazards. Above 5,800 feet (1,768 m), plantations positioned on minor ridges are most apt to escape snow damage.

Either *Picea* or *P. ponderosa,* depending on site moisture, have the greatest yield capability in ABGR/VAGL. *Abies grandis* is readily infected by heartrot, which can result in high basal areas of unsound wood.

The Shrub Layer

Shrub layer succession in ABGR/VAGL is relatively complex compared to some habitat types in central Idaho. This is due mainly to the greater production potential of these sites, which leads to greater vegetal diversity. Environmental variation within the habitat type also contributes to successional diversity. The dry extreme of ABGR/VAGL generally merges with the grand fir/white spirea habitat type and the moist extreme merges with grand fir/mountain maple. Shrub layer succession near these extremes often resembles that of the adjacent site rather than a modal ABGR/VAGL site.

Relative successional amplitudes of major shrub species in ABGR/VAGL provide the basis for shrub layer classification and are shown in figure 9. These amplitudes were derived from many field observations and sample data (appendix B). They are meaningful only in a relative sense because there is no scale for measurement. Ideally, relative amplitudes should be established through studies of many permanent plots over many decades, but such studies are rare. Consequently, accuracy of relative amplitudes (fig. 9) varies from well-established trends to the authors' best guess. The certainty of this accuracy is greatest for the species farthest apart. For example, *Ceanothus* and *Ribes* clearly have less successional amplitude than *Vaccinium* (fig. 9), but the relative amplitudes of *Symphoricarpos* versus *Rubus* are less certain. Consequently, when determining relative amplitudes one must use the "philosophy of successive approximations" (Poore 1962) as a scientific basis for developing hypotheses for each species followed by testing through field observation and data analysis.

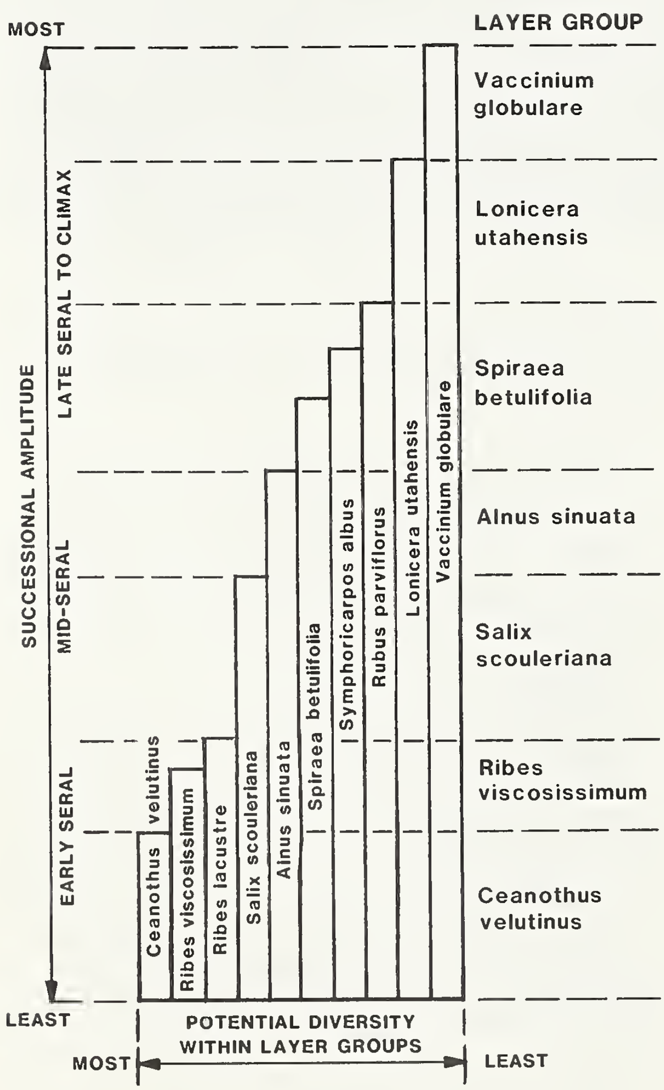

Figure 9—Relative successional amplitudes of major shrub species in ABGR/VAGL h.t.

Among the 85 shrub layers sampled, there are seven successional indicator species and three alternates. The alternate species occur in only part of the habitat type and are grouped with more widespread primary indicators having similar successional strategies and amplitudes. For instance, *Ribes lacustre* was grouped with *R. viscosissimum* because of similar seed storage capabilities and germination responses to scarification; *Symphoricarpos albus* and *Rubus parviflorus* were grouped with *Spiraea betulifolia* because of similar rhizomatous growth capabilities in late seral communities. A few other taxa, *Pachistima, Rosa*, and *Shepherdia*, were common throughout ABGR/VAGL but were only occasionally well represented and so were not used as indicator species (appendix B).

From the relative amplitudes (fig. 9), a succession classification diagram for shrub layers is easily constructed (fig. 10). The classification consists of seven shrub layer groups and 28 layer types (fig. 10). Of the 28 possible layer types, 23 occur in the present data set. The remaining five layer types may be found with more reconnaissance, may appear only after uncommon disturbances (or disturbance combinations), or may be rare under any circumstance.

The classification diagram (fig. 10) is, in turn, easily converted to a systematic key for field use (table 7). Indicator species (of layer groups) appearing early in the key have the least successional amplitude (greatest vulnerability) and so have greater indicator value than species with more amplitude, which appear progressively later in the key. This same ranking of indicator value is used to select the dominant indicator for layer types when several species codominate the site. Alternate indicator species (fig. 9) appear with their appropriate primary indicator throughout the key (table 7).

Average and range of years since disturbance of sampled layer types appear in appendix B. The low extreme of each range is meaningless because any layer type could have been recently disturbed; in these cases only disturbance intensity would vary between layer types. The upper yearly extremes and averages, which may reflect progression through several layer types, show a gradual though sporadic increase from left to right into successionally older shrub layers. This general progression of both years and layer types demonstrates that both entities delineate time, though in different ways.

Layer Group								
Vaccinium globulare							VAGL -VAGL n = 13	
Lonicera utahensis						LOUT -LOUT n = 2	LOUT -VAGL n = 14	
Spiraea betulifolia					SPBE -SPBE n = 4	SPBE -LOUT n = 1	SPBE -VAGL n = 5	
Alnus sinuata				ALSI -ALSI	ALSI -SPBE n = 1	ALSI -LOUT	ALSI -VAGL n = 1	
Salix scouleriana			SASC -SASC n = 3	SASC -ALSI n = 2	SASC -SPBE n = 4	SASC -LOUT n = 1	SASC -VAGL n = 8	
Ribes viscosissimum		RIVI -RIVI n = 3	RIVI -SASC n = 1	RIVI -ALSI n = 2	RIVI -SPBE	RIVI -LOUT n = 4	RIVI -VAGL n = 2	
Ceanothus velutinus	CEVE -CEVE n = 6	CEVE -RIVI n = 1	CEVE -SASC n = 1	CEVE -ALSI	CEVE -SPBE n = 2	CEVE -LOUT	CEVE -VAGL n = 4	

Climax ↑ TIME (Successional Age) ↓ Seral

Most ↑ SUCCESSIONAL INDICATOR (Successional Amplitude) ↓ Least

DOMINANT
Less ← (Structural Development) → More

Figure 10—Succession classification diagram of the shrub layer in the ABGR/VAGL h.t.

Table 7—Key to shrub layer groups and layer types, with ADP codes, in ABGR/VAGL h.t.

Key	Result	ADP codes
1. *Ceanothus velutinus* well represented[1] (Choose first condition that fits)	CEVE Layer Group	107
1a. *Ceanothus* dominant	CEVE-CEVE Layer Type	107.107
1b. *Ribes* spp. dominant or codominant	CEVE-RIVI Layer Type	107.131
1c. *Salix scouleriana* dominant or codominant	CEVE-SASC Layer Type	107.137
1d. *Alnus sinuata* dominant or codominant	CEVE-ALSI Layer Type	107.104
1e. *Spiraea*, (incl. *Symphoricarpos albus*, or *Rubus parviflorus*) dominant or codominant	CEVE-SPBE Layer Type	107.142
1f. *Lonicera utahensis* dominant or codominant	CEVE-LOUT Layer Type	107.115
1g. *Vaccinium globulare* dominant or codominant	CEVE-VAGL Layer Type	107.146
1. *Ceanothus* poorly represented	2	
2. *Ribes viscosissimum* (incl. *R. lacustre*) well represented (Choose first condition that fits)	RIVI Layer Group	131
2a. *Ribes* spp. dominant	RIVI-RIVI Layer Type	131.131
2b. *Salix scouleriana* dominant or codominant	RIVI-SASC Layer Type	131.137
2c. *Alnus sinuata* dominant or codominant	RIVI-ALSI Layer Type	131.104
2d. *Spiraea* (incl. *Symphoricarpos albus* and *Rubus parviflorus*) dominant or codominant	RIVI-SPBE Layer Type	131.142
2e. *Lonicera utahensis* dominant or codominant	RIVI-LOUT Layer Type	131.115
2f. *Vaccinium globulare* dominant or codominant	RIVI-VAGL Layer Type	131.146
2. *Ribes* spp. poorly represented	3	
3. *Salix scouleriana* well represented (Choose first condition that fits)	SASC Layer Group	137
3a. *Salix* dominant	SASC-SASC Layer Type	137.137
3b. *Alnus sinuata* dominant or codominant	SASC-ALSI Layer Type	137.104
3c. *Spiraea* (incl. *Symphoricarpos albus* and *Rubus parviflorus*) dominant or codominant	SASC-SPBE Layer Type	137.142
3d. *Lonicera utahensis* dominant or codominant	SASC-LOUT Layer Type	137.115
3e. *Vaccinium globulare* dominant or codominant	SASC-VAGL Layer Type	137.146
3. *Salix* poorly represented	4	
4. *Alnus sinuata* well represented (Choose first condition that fits)	ALSI Layer Group	104
4a. *Alnus* dominant	ALSI-ALSI Layer Type	104.104
4b. *Spiraea* (incl. *Symphoricarpos albus* and *Rubus parviflorus*) dominant or codominant	ALSI-SPBE Layer Type	104.142
4c. *Lonicera utahensis* dominant or codominant	ALSI-LOUT Layer Type	104.115
4d. *Vaccinium globulare* dominant or codominant	ALSI-VAGL Layer Type	104.146
4. *Alnus* poorly represented	5	
5. *Spiraea betulifolia* (incl. *Symphoricarpos albus* and *Rubus parviflorus*) well represented	SPBE Layer Group	142
5a. *Spiraea* (incl. *Symphoricarpos albus* and *Rubus parviflorus*) dominant	SPBE-SPBE Layer Type	142.142
5b. *Lonicera utahensis* dominant or codominant	SPBE-LOUT Layer Type	142.115
5c. *Vaccinium globulare* dominant or codominant	SPBE-VAGL Layer Type	142.146
5. *Spiraea*, *Symphoricarpos albus*, and *Rubus* poorly represented	6	
6. *Lonicera utahensis* well represented (Choose first condition that fits)	LOUT Layer Group	115
6a. *Lonicera* dominant	LOUT-LOUT Layer Type	115.115
6b. *Vaccinium globulare* dominant or codominant	LOUT-VAGL Layer Type	115.146
6. *Lonicera* poorly represented	7	
7. *Vaccinium globulare* well represented	VAGL Layer Group	146
7a. *Vaccinium* dominant	VAGL-VAGL Layer Type	146.146
7. *Vaccinium* poorly represented	depauperate or unclassified shrub layer.	

[1] "Well represented" means canopy coverage $\geq$5 percent. "Dominant" refers to greatest canopy coverage regardless of height, "codominant" refers to nearly equal canopy coverage. When keying to layer type, choose first condition that fits.

CEANOTHUS VELUTINUS LAYER GROUP (CEVE L.G.)

Ceanothus velutinus is a shade-intolerant nonrhizomatous shrub with values for big-game browse, songbird habitat (Thomas 1979), and nitrogen fixation (Youngberg and Wollum 1976). It is often the first shrub to dominate following wildfire or clearcutting and broadcast burning. *Ceanothus* declines substantially in the shade of other vegetation. It is known for its ability to store viable seed in the soil and duff for at least 200 to 300 years and to germinate readily following a heat treatment (Reed 1974). Kramer (1984) found viable *Ceanothus* seed buried in 75 percent of the ABGR/VAGL sites that he sampled. In ABGR/VAGL, *Ceanothus* can attain heights of 5 to 6 feet (1.5 to 1.8 m) in about 14 years. These heights contrast sharply with less productive habitat types such as Douglas-fir/pinegrass where *Ceanothus* reaches only about 3 feet (0.9 m) (Steele and Geier-Hayes 1984).

The CEVE l.g. represents some of the most common early seral shrub layers in ABGR/VAGL. Of the seven CEVE layer types that may occur in ABGR/VAGL (fig. 10), only the CEVE-ALSI and CEVE-LOUT layer types were not found. CEVE-ALSI is probably quite rare because *Ceanothus* and *Alnus* seldom occur on the same site; *Lonicera*-dominated layer types tend to be uncommon.

The CEVE l.g. is typically a response to various intensities or frequencies of burning, but can also appear following scarification (fig. 11). It is perhaps the easiest shrub layer group to achieve following disturbance and responds dependably to burning on slopes with good cold air drainage. CEVE layer types are not apt to appear in areas that accumulate cold air and that act as frost pockets. Such conditions may also be too cold for *Pinus ponderosa* pine to grow properly and better suited for *P. contorta* and *Picea engelmannii*. The CEVE l.g. rarely appears on sites where *Alnus sinuata* can dominate. Apparently the *Ceanothus* seed does not store successfully on these wetter sites (Kramer 1984). In these wetter situations, *Picea* is apt to be more successful than *Pinus ponderosa*. With proper site treatment, the CEVE l.g. is a practical cover for protecting disturbed sites. A dense canopy of *Ceanothus* (generated by a high-intensity

Figure 11—A *Ceanothus velutinus* - *Ceanothus velutinus* shrub layer type near Price Valley Guard Station. This 6-year-old seedtree cut was heavily scarified but not burned. A patchy cover of *Ceanothus* resulted from the scarification and now dominates the site. *Ribes* is scarce; apparently there was little seed in the soil. Adjacent unlogged sites suggest that the predisturbance shrub layer was a dense climax VAGL-VAGL layer type. Now *Vaccinium* is only present in trace amounts.

prescribed burn) will deter livestock and erosion; a light canopy (generated by a low-intensity burn) can provide shelter for *Pseudotsuga* seedlings. Following clearcutting and burning in the Oregon Cascade Range, *Ceanothus* enhanced stockability and growth of naturally established coastal *Pseudotsuga* seedlings for about the first 7 years, after which competition began to outweigh the benefits (Youngberg and others 1979). The improved performance of *Pseudotsuga* was attributed to higher nitrogen levels, amelioration of microenvironment, or a combination of these effects. In another study in the Oregon Cascade Range (Petersen and Newton 1985), planted coastal *Pseudotsuga* benefited from an herbicide treatment of dense *Ceanothus* and other vegetation 5 years after planting. Plantations that received the same treatment at 10 years of age benefited substantially less. Reduction of *Ceanothus* canopy by cutting the stems at year 10 had no effect on *Pseudotsuga* height growth.

RIBES VISCOSISSIMUM LAYER GROUP (RIVI L.G.)

Ribes viscosissimum and *R. lacustre* are characteristically early seral nonrhizomatous shrubs, often the first to dominate well-scarified sites that lack rhizomatous shrubs. Having a low tolerance for shade, these *Ribes* begin declining shortly after a canopy taller than their own develops. The *Ribes*, however, seem to maintain themselves longer toward climax than does *Ceanothus* (appendix B) and so are considered slightly less vulnerable to succession (fig. 9). Like *Ceanothus*, numerous seed of *Ribes* remain viable in the soil and duff long after the parent shrubs have disappeared. Kramer (1984) found *Ribes* seed buried in 69 percent of the ABGR/VAGL sites that he sampled. Although *R. viscosissimum* may occur throughout ABGR/VAGL, *R. lacustre* is more restricted to wetter sites that can also support *Alnus* and *Picea*.

The classification diagram (fig. 10) shows six possible layer types in the RIVI l.g. Only one, RIVI-SPBE, was not found, but it is apt to appear following scarification of shrub layers in which *Spiraea* is well represented. Although *Lonicera*-dominated shrub layers are uncommon, four examples of RIVI-LOUT were found in clearcuts. In all four cases, apparently a LOUT-VAGL layer type had received shallow scarification so as to remove the *Vaccinium*, but the more deeply rooted *Lonicera* had survived the bulldozer blade and resprouted. The *Ribes* had germinated from buried seed following the scarification.

In general, the RIVI l.g. originates from various types of scarification without burning (fig. 12). It is most common in scarified portions of past pile-and-burn operations and rarely occurs on intensely burned areas. The RIVI l.g., and especially the RIVI-RIVI layer type, generate the least competition for tree seedlings of any early to midseral shrub layer in ABGR/VAGL. The maximum height of *Ribes* is about 3 feet (0.9 m), and although this height is attained within 5 years, the canopy is sparse and should not outcompete ponderosa pine seedlings.

SALIX SCOULERIANA LAYER GROUP (SASC L.G.)

Salix scouleriana is a nonrhizomatous shrub that has high value for big-game browse (appendix B). It can also provide nesting and feeding habitat for small birds and site protection for conifer seedlings. Though only slightly tolerant of shade, its tall growth habit—up to 24 feet (7.3 m) in ABGR/VAGL—and sprouting ability enable this *Salix* to persist in small openings on well-timbered sites. Its light, windblown seeds are dispersed in late spring, have a short-lived viability, and require moist mineral soil for germination (Brinkman 1974).

The SASC l.g. represents a midseral stage of shrub layer succession and consists of five layer types in ABGR/VAGL (fig. 10). All of these have been sampled, with SASC-VAGL being the most common.

In the past, this layer group resulted from stand-destroying wildfires, but today broadcast burn operations do not always burn hot enough to create an adequate seedbed for *Salix*. Such treatments usually generate a CEVE layer type which lacks *Salix* and bypasses the SASC l.g. during succession. SASC layer types have developed following mechanical scarification in clearcuts, especially where exposed soil was mounded so as to trap water behind the mounds, thus creating well-watered seedbeds of mineral soil. Most stands sampled in this layer group had received machine scarification from pile-and-burn or contour terrace operations 11 to 24 years ago (fig. 13) or experienced a severe wildfire over 50 years ago.

The SASC l.g. may enhance *Pseudotsuga* or *Picea* establishment by protecting the site and providing partial shade, but it is a formidable competitor of *Pinus ponderosa*. Having a low tolerance for shade, the pine must outgrow *Salix* in order to survive. This is barely possible when *Salix* seedlings are involved because planted pine and *Salix* seedlings have similar growth rates for about the first 6 years. But when the *Salix* arises from stump sprouts that can outgrow the pine in the first year, the pine has little chance for survival. Even when contour terraces are installed next to *Salix* stumps, the pine is shaded out by the height and lateral spread of the *Salix*. In full sunlight, *Salix* stumps can produce tall rounded shrubs up to 16 feet (4.9 m) in diameter. Consequently, uncut stands with a *Salix* density of at least one every 16 feet (4.9 m) may lack potential growing space for pine seedlings following clearcutting. Such sites may require special mechanical or chemical treatment following clearcutting where pine plantations are a management objective.

ALNUS SINUATA LAYER GROUP (ALSI L.G.)

Alnus sinuata is a nonrhizomatous seral shrub that has little forage value but provides habitat for small birds and fixes nitrogen in the soil (Mitchell 1968). Though only slightly shade tolerant, its widely spreading growth habit enables it to persist on timbered sites by intercepting

Figure 12—A *Ribes viscosissimum - Ribes viscosissimum* shrub layer type northeast of Bear, ID. This site was clearcut and scarified without burning 11 years ago. It was planted to ponderosa pine, Douglas-fir, and western larch the following year. Both *Ribes viscosissimum* and *R. lacustre* responded to the scarification and now codominate the shrub layer. This shrub layer type creates the least competition for tree seedlings of any shrub layer in ABGR/VAGL h.t.

Figure 13—A *Salix scouleriana - Vaccinium globulare* shrub layer type near Bessie Gulch northeast of Bear, ID. This site was clearcut and lightly scarified by a dozer-pile and burn treatment 11 years ago. Ponderosa pine and Douglas-fir were planted the following year; lodgepole pine established naturally. *Salix*, mainly from seedlings, is established where the soil had been exposed. *Vaccinium* survived the shallow scarification treatment and continues to have the greatest shrub coverage. No other shrub species are well represented. As the tree layer develops, this shrub layer will likely progress directly to a VAGL-VAGL layer type.

sunlight that passes through the tree canopy. *Alnus* has a light, wind-disseminated seed that requires moist mineral soil for germination. Although it generally forms thickets from seed, the *Alnus* can also sprout from stumps and reach a maximum height of 10 to 13 feet (3.0 to 4.0 m). High coverages of *Alnus* occur in only the wetter portions of ABGR/VAGL and indicate sites suitable for *Picea engelmannii* and generally unsuitable for *Ceanothus* and possibly *Pinus ponderosa*.

The ALSI l.g. represents midseral shrub layers in ABGR/VAGL and consists of four layer types, two of which were found (fig. 10). It is not widespread in ABGR/VAGL but can appear unexpectedly following clearcutting and scarification. The rapid growth rate of *Alnus* may preclude success of ponderosa pine seedlings, making it imperative to recognize potential *Alnus* sites before planting. The presence of *Alnus* is the best indicator of such conditions, but the presence of *Actaea, Trautvetteria, Circaea*, or a high density of *Picea* generally indicate sites wet enough for *Alnus* invasion.

SPIRAEA BETULIFOLIA LAYER GROUP (SPBE L.G.)

Spiraea betulifolia is a moderately shade-tolerant rhizomatous shrub with root development well down into the soil profile. Mechanical scarification and stripping seldom remove completely the *Spiraea* root system, which will resprout within the next growing season. *Spiraea* also provides moderate amounts of forage for mule deer in summer and fall (Kufeld and others 1973).

Symphoricarpos albus and *Rubus parviflorus* may be slightly more shade tolerant than *Spiraea* (fig. 9), but are treated as successional equivalents in ABGR/VAGL because neither species appears frequently enough to justify a separate layer group. Like *Spiraea*, these two species also develop extensive rhizomes that usually resprout following scarification of the site. They also provide moderate forage for deer and elk as well as food for black bear (appendix B).

The SPBE l.g. occurs mainly in drier portions of ABGR/VAGL. It is treated here as a late seral stage of shrub layer succession but may represent a near-climax stage (especially SPBE-VAGL) when occurring on sites transitional to the grand fir/white spirea habitat type. The SPBE l.g. consists of three layer types, all of which were sampled (fig. 10). The SPBE-SPBE and SPBE-LOUT layer types in all sample plots resulted from clearcutting and thorough scarification, usually a pile-and-burn operation, 4 to 9 years ago (fig. 14). Although *Ribes* was present on all sites, the amount of buried *Ribes* seed was apparently inadequate to produce the *Ribes* layer types typical of this site treatment. The *Spiraea* and *Lonicera* likely resprouted from residual roots that survived the scarification. The SPBE-VAGL layer type occurred mainly beneath a tree canopy and was the result of uninterrupted succession following the last wildfire 30 to 80 years ago.

LONICERA UTAHENSIS LAYER GROUP (LOUT L.G.)

Lonicera utahensis is a shade-tolerant, nonrhizomatous shrub that is able to persist beneath a near-climax tree canopy. As the shrub layer approaches climax, *Lonicera* slowly loses its foothold because of its inability to increase vegetatively. Upon disturbance, the deeply rooted *Lonicera* often survives scarification and broadcast burns. In full sun, it develops a well-rounded canopy about 3 feet (0.9 m) tall and has moderate to high forage value for deer, elk, and black bear (appendix B). The fleshy coated seeds are probably dispersed by birds, rodents, and bears, but natural seedbed conditions are unknown. Kramer (1984) sampled buried seed composition of 16 stands in ABGR/VAGL but found no viable seeds of *Lonicera*, yet all of those stands contained the living shrub. Thus it appears that *Lonicera* seed does not long remain viable in soil or duff.

The LOUT l.g. consists of two layer types and indicates a near-climax shrub layer (fig. 10). Conceivably it could result from light disturbance beneath a partial tree canopy as in the case of a shelterwood system for *Pseudotsuga* or *Abies*. It is known to occur following clearcutting with scarification (LOUT-LOUT, fig. 15) or clearcutting with no site treatment (LOUT-VAGL). In these cases, the *Lonicera* appears to have been established prior to clearcutting and simply resprouted from root crowns, its vigor renewed by the increased sunlight. In most cases, however, the LOUT l.g. was found beneath mature to old-growth timber that experienced a surface fire about 80 years ago. Of the two layer types in the LOUT l.g., only the LOUT-VAGL layer type is common (fig. 10). The LOUT-LOUT layer type is apparently rare.

VACCINIUM GLOBULARE LAYER GROUP (VAGL L.G.)

Vaccinium globulare is a shade-tolerant rhizomatous shrub that has high food value for deer, elk, and black bear (appendix B). It has a relatively shallow root system making it quite vulnerable to scarification and high-intensity burns. Low-intensity burns that do not destroy the *Vaccinium* rhizomes, can stimulate new shoots and berry production (Miller 1977). Reducing overstory shade without disturbing the *Vaccinium* may also increase berry production (Minore 1984). The seeds, which are dispersed by birds and mammals, may remain stored in the soil and litter. They will germinate in partial shade on moist mineral soil.

The VAGL l.g., which consists only of VAGL-VAGL, occurs mainly in old-growth stands but can also occur where the tree layer has been removed without killing the *Vaccinium* or allowing other species to establish. If the VAGL l.g. is disturbed, the resulting layer type will depend on the kind and intensity of disturbance, the amount of sunlight available, the species and quantities of available windblown seed and seed stored in the soil and duff, and the composition of remnant seral shrubs in the stand.

Figure 14—A *Spiraea betulifolia* - *Lonicera utahensis* shrub layer type northwest of Tamarack, ID. *Spiraea* and *Lonicera* both survived the clearcut and scarification treatment that occurred here 9 years ago. They are the only shrubs well represented; together they codominate the site. Being a late seral stage, this shrub layer type will persist long after the planted pines have formed a mature canopy.

Figure 15—A *Lonicera utahensis* - *Lonicera utahensis* shrub layer type in the Squaw Creek drainage northwest of Smith's Ferry, ID. This site was clearcut 15 years ago. Contour strips were scraped across the slope in order to plant lodgepole pine. The *Lonicera*, which existed prior to logging, has increased its canopy in response to the increased sunlight and now dominates the shrub layer. *Vaccinium*, the only other shrub species well represented, was reduced somewhat by the logging disturbance.

MANAGEMENT IMPLICATIONS

The previous sections describe some layer groups that can be achieved through prescribed site treatments. Actual layer types within the group can often be projected on a stand-by-stand basis from species composition. When considering alternative shrub layers resulting from different site treatments, land managers may wish to assess relative forage value of layer types for big game and livestock. Such values can be estimated from relative palatability ratings of plant species for elk (Kufeld 1973), deer (Kufeld and others 1973), cattle and sheep (USDA-FS n.d.), and black bear (Beecham 1981). The scale in these studies of 1 to 3 was expanded to 2 to 6 so as to emphasize the differences in palatability values. The relative palatability value for each plant species is listed in appendix B. This value was multiplied by the percentage constancy and average canopy cover (appendix B) for that species in a given layer type. This step was repeated for all species in the layer type. The sum of all such products within a layer type resulted in a forage index value for that particular layer type. The index values were then reduced to classes in order to simplify forage value assessments and to eliminate the impression of high precision between values (table 8).

These index classes reflect forage potential on a relative basis but do not necessarily reflect actual use, which is affected by juxtaposition of the surrounding vegetational types. Some index values may be biased by inconsistent proportions of canopy cover to shrub volume. Likewise actual palatability within a species can vary with plant vigor; however, other sources of variation common to this type of comparison have been reduced. For instance, the possibility of ecotypes within a plant species is reduced by restricting the data to one habitat type. Individual animals may have slightly different forage preferences, but all possible layer types can be made available to the same group of animals. Plant species palatabilities are listed by season to accommodate seasonal forage preferences. In spite of the shortcomings inherent with these kinds of comparisons, the forage index classes can provide general

Table 8—Relative index classes to big-game and livestock forage preferences by shrub layer type in ABGR/VAGL h.t.[1]

Layer group layer type	No. of stands	Deer		Elk		Cattle	Sheep	Black bear		
		SU[2]	W	SU	W	SU	SU	SP	SU	F
Ceanothus velutinus										
CEVE-CEVE	6	[3]5	3	5	4	2	2	0	1	1
CEVE-RIVI	1	3	3	4	3	2	2	0	1	1
CEVE-SASC	1	4	3	4	3	1	2	0	0	0
CEVE-SPBE	2	4	3	4	4	2	3	0	1	1
CEVE-VAGL	4	5	4	6	4	2	4	1	3	2
Ribes viscosissimum										
RIVI-RIVI	3	3	3	4	4	1	3	1	3	2
RIVI-SASC	1	3	3	3	2	1	2	1	2	1
RIVI-ALSI	2	4	5	6	5	3	4	1	3	2
RIVI-LOUT	4	3	3	4	4	1	2	1	3	2
RIVI-VAGL	2	4	3	5	3	2	3	1	4	3
Salix scouleriana										
SASC-SASC	3	4	4	4	4	1	3	0	1	1
SASC-ALSI	2	4	3	4	4	2	4	1	2	1
SASC-SPBE	4	4	3	5	3	2	3	1	2	1
SASC-LOUT	1	3	3	5	3	2	2	1	3	2
SASC-VAGL	8	6	5	6	4	2	4	2	5	3
Alnus sinuata										
ALSI-SPBE	1	2	2	3	2	1	2	1	2	1
ALSI-VAGL	1	6	5	7	3	3	4	2	6	4
Spiraea betulifolia										
SPBE-SPBE	4	1	1	1	1	1	1	0	0	0
SPBE-LOUT	1	1	1	2	1	1	1	0	1	1
SPBE-VAGL	5	5	3	5	3	2	3	1	4	3
Lonicera utahensis										
LOUT-LOUT	2	3	3	4	3	2	2	1	3	2
LOUT-VAGL	14	5	4	5	2	2	3	2	5	3
Vaccinium globulare										
VAGL-VAGL	13	3	2	3	1	1	2	1	3	2

[1]Based on palatability ratings by Kufeld (1973), Kufeld and others (1973), USDA-FS (n.d.), and Beecham (1981).
[2]SP = spring (March, April, May); SU = summer (June, July, August); F = fall (September, October, November); W = winter (December, January, February).
[3]Code to index classes: 0 = 0-50; 1 = 51-150; 2 = 151-250; 3 = 251-350; 4 = 351-450; 5 = 451-550; 6 = 551-650; 7 = 651-750.

guidelines to relative browse potential for specific wildlife and range objectives as well as multifunctional planning. Range and wildlife managers who may have better species palatability ratings for a local area can easily recalculate the forage indexes from appendix B, reduce the indexes to index classes (table 8), and apply the results to their area.

Forage index classes (table 8) vary according to kinds and amounts of plant species comprising the layer type. Because early seral layer types may contain a wider variety of plants than later stages, a greater data base is often needed to reflect actual modal conditions and forage indexes in these early stages. When the same layer type occurs in different habitat types or phases, variability of the index may increase with potential of the site and more samples may be needed for the more productive site. The index value, however, is most affected by coverages of the most palatable species and does not necessarily increase with site productivity although this often is the case. Ranking of species' nutritional value between habitat types could add refinement to the index values. Such considerations are needed when comparing relative significance of forage index classes.

Deer—Of the shrub layer types sampled in ABGR/VAGL, the highest forage index for summer deer herds occurred in the SASC-VAGL and ALSI-VAGL layer types (table 8). This was due mainly to the high coverage of *Vaccinium* (highly palatable) in these stands. Layer types having the second highest forage index include CEVE-CEVE, CEVE-VAGL, SPBE-VAGL, and LOUT-VAGL. Thus it appears that most *Vaccinium*-dominated shrub layers are important for summer mule deer in ABGR/VAGL. All of the above layer types, except CEVE-CEVE, can be achieved by simply reducing the tree canopy where *Vaccinium* dominates the undergrowth. The actual layer type that results will depend on total shrub composition in the stand. In contrast, scarification, which usually produces the RIVI l.g. in clearcut areas, will eliminate much of the shallow-rooted *Vaccinium* and the high summer forage value for deer (table 8). In clearcuts, burning to produce a CEVE-CEVE layer type, rather than scarification, may be a more desirable method of site preparation in key mule deer areas.

In winter, forage values are low to moderate throughout ABGR/VAGL succession. The SASC-VAGL and ALSI-VAGL layer types still have the highest value (table 8), but snow depths likely preclude much foraging on these sites. The RIVI-ALSI layer type also ranked high due to the higher winter forage value of *Ribes* (appendix B).

Elk—The highest forage indexes for summer elk include the same layer types as for deer and for similar reasons. The ALSI-VAGL layer type ranked highest, followed by CEVE-VAGL, RIVI-ALSI, and SASC-VAGL (table 8). These layer types have a forage index of 6 or above for summer elk. Forage values for elk may be slightly greater than for deer in ABGR/VAGL, especially when grazing values of the herb layer (see herb layer section) are also considered.

Forage indexes for winter elk herds are low to moderate. The highest values occur in the CEVE, RIVI, and SASC l.g.'s (table 8).

Cattle—Shrub forage values for cattle are low throughout ABGR/VAGL succession. These low indexes reflect the generally low palatability of most major shrub species in ABGR/VAGL. But even when grazing values of the herbaceous layer are included, total forage value for cattle is generally less in ABGR/VAGL than for deer and elk.

Sheep—Forage values for sheep range from low to moderate. The highest values occurred in the CEVE-VAGL, RIVI-ALSI, SASC-ALSI, SASC-VAGL, and ALSI-VAGL layer types. All of these layer types, however, also ranked as high or higher for either deer or elk (table 8).

Black Bear—In spring, shrub forage values for black bear are low throughout ABGR/VAGL succession but increase substantially with development of various fruit crops. In summer, the ALSI-VAGL layer type followed by SASC-VAGL and LOUT-VAGL (table 8) have the highest index classes. In all cases, these high indexes hinge on the dominant coverage of *Vaccinium*, the major berry producer. These three layer types were also among those ranking highest for deer and elk, which emphasizes the often high value of midseral to late seral shrub layer conditions for big game in general. In the fall, most forage indexes for bear decline by at least one class, but the ALSI-VAGL layer type still has the highest value. Fall fruiting shrubs, particularly *Sorbus*, contribute to the higher fall indexes in some of these layer types.

Planted Tree Seedlings and Shrub Competition—Potential shrub competition with tree seedlings is a function of existing vegetation, seed availability, site treatment, and habitat type or phase. The habitat type or phase classifies the environment, which in turn determines which species can occur on the site and the magnitude of their potential roles. Table 9 lists the shrub species most likely to occur in ABGR/VAGL and their successional role in this habitat type. Predicting what species might occur

Table 9—Successional roles of shrub species in ABGR/VAGL h.t.

ADP No.	Species	Abbreviation	Role[1]
102	*Acer glabrum*	ACGL	c
104	*Alnus sinuata*	ALSI	(S)
105	*Amelanchier alnifolia*	AMAL	s
150	*Artemisia tridentata*	ARTR	a
203	*Berberis repens*	BERE	(s)
107	*Ceanothus velutinus*	CEVE	(S)
108	*Chrysothamnus nauseosus*	CHNA	a
109	*Cornus stolonifera*	COST	a
111	*Holodiscus discolor*	HODI	a
114	*Lonicera involucrata*	LOIN	a
115	*Lonicera utahensis*	LOUT	S
118	*Pachistima myrsinites*	PAMY	(c)
122	*Physocarpus malvaceus*	PHMA	(c)
123	*Prunus emarginata*	PREM	(s)
128	*Ribes cereum*	RICE	a
158	*Ribes hudsonianum*	RIHU	a
130	*Ribes lacustre*	RILA	(S)
131	*Ribes viscosissimum*	RIVI	S
133	*Rosa gymnocarpa*	ROGY	s
161	*Rosa nutkana*	RONU	(s)
136	*Rubus parviflorus*	RUPA	(S)
137	*Salix scouleriana*	SASC	S
164	*Sambucus cerulea*	SACE	(s)
138	*Sambucus racemosa*	SARA	s
139	*Shepherdia canadensis*	SHCA	s
140	*Sorbus scopulina*	SOSC	s
142	*Spiraea betulifolia*	SPBE	S
143	*Symphoricarpos albus*	SYAL	(S)
163	*Symphoricarpos oreophilus*	SYOR	(s)
146	*Vaccinium globulare*	VAGL	C
148	*Vaccinium scoparium*	VASC	a

[1]S = major seral a = accidental
s = minor seral ( ) = occurs in only part of the habitat type, usually the wetter portion or the warmer-drier portion.
C = major climax
c = minor climax

or dominate by simply inspecting a site prior to disturbance is not always possible. Old-growth stands may contain a multitude of early seral species in the form of buried seed (Kramer 1984); other species establish by windblown seed. Table 10 shows which shrubs in ABGR/VAGL store seed in the soil and important methods of seed dissemination, vegetative increase, and germination response to site treatment. For instance, if *Ribes* occurs in the stand, the existing *Ribes* canopy may increase somewhat in a clearcut with no site preparation (table 10). If the clearcut is scarified, existing plants will increase their canopies due to the clearcut, but the scarification will also reduce total canopy cover and cause *Ribes* seed to germinate in proportion to the scarification. Potential shrub competition for a given site is best estimated by noting kinds and amounts of existing shrubs on that site, the other species that may occur (table 9), and reactions of all species to the site treatment planned (table 10). In contrast, generalized descriptions of site treatment and potential shrub responses tend to represent an average stand condition. Such predictions can be misleading for site-specific management because few stands would fit the average, thus many plantations could be lost to unexpected competition.

Duration of the competition depends on height-age interactions of tree seedlings with the shrubs and shrub density. As noted (table 10), existing and potential shrub densities can be regulated by the kind and intensity of site treatment (guarding against the possibility of increasing one undesirable shrub species while reducing another). Height-age interactions in ABGR/VAGL are generalized in figure 16. If free from suppression, properly planted *Pinus ponderosa* can outgrow most shrubs germinating from seed at the time of planting. Only *Ribes* will substantially overtop the pine within the first 6 years (fig. 16), but a *Ribes* canopy is usually sparse and does not strongly suppress pine growth. The *Ribes* growth curve (fig. 16) is

Table 10—Responses of major shrub species to various disturbances

Species	Seed transport, reproduction methods	Maximum heights	Type of disturbance CC, NP	SC, MS	CC, MS	CC, BB	WF
		Feet					
VAGL	Birds, mammals; stored in soil (23% viable).[1] Germinates in partial shade on moist mineral soil. Increases by shallow rhizomes.	2½ - 3½	v	V-s	v	v	v
LOUT	Birds, mammals; not stored in soil. Root crowns resprout following fire or logging.	2½ - 3½	v	v	v	v	v
RUPA	Birds, mammals; stored in soil (14% viable). Increases by rhizomes.	2 - 3	V	V	V	V	V
SYAL	Birds, mammals; not stored in soil. Increases by rhizomes.	1 - 1½	V	v	V	V	V
SPBE	No obvious transport; not stored in soil. Increases by rhizomes.	1 - 2	V	v	V	V	V
ALSI	Wind; not stored in soil. Germinates on moist soil in full sun. Stumps resprout.	10 - 13	v	v	v-S	v-s	v-s
SASC	Wind; not stored in soil. Germinates on moist mineral soil in full sun. Stumps resprout.	20 - 24	V	v	V-s	V-s	V-s
RIVI	Birds, mammals; stored in soil (96% viable). Germinates on mineral soil in full sun.	2½ - 3½	v	v-s	v-S	s	s
CEVE	No obvious transport; stored in soil (91% viable). Germinates mainly from burning and partially from scarification in full sun.	5 - 6	v	v	v-s	S	S

DISTURBANCE CODES:

CC, NP = Clearcut, no site preparation
SC, MS = Shelterwood cut, mechanical scarification
CC, MS = Clearcut, mechanical scarification
CC, BB = Clearcut, broadcast burned
WF = Stand-destroying wildfire

RESPONSE CODES:

V = Major vegetative response (coverage increases from existing plants and vigorous sprouting following tree removal but is offset by treatment intensity).

v = Minor vegetative response (coverage increases either from just the existing plants following tree removal or from existing plants and nonvigorous sprouting but is offset by treatment intensity).

S = Major response from seed (coverage increase depends on amount of viable seed available and is enhanced by treatment intensity).

s = Minor response from seed (same criteria as for S).

[1]Stored seed viabilities are from Kramer (1984).

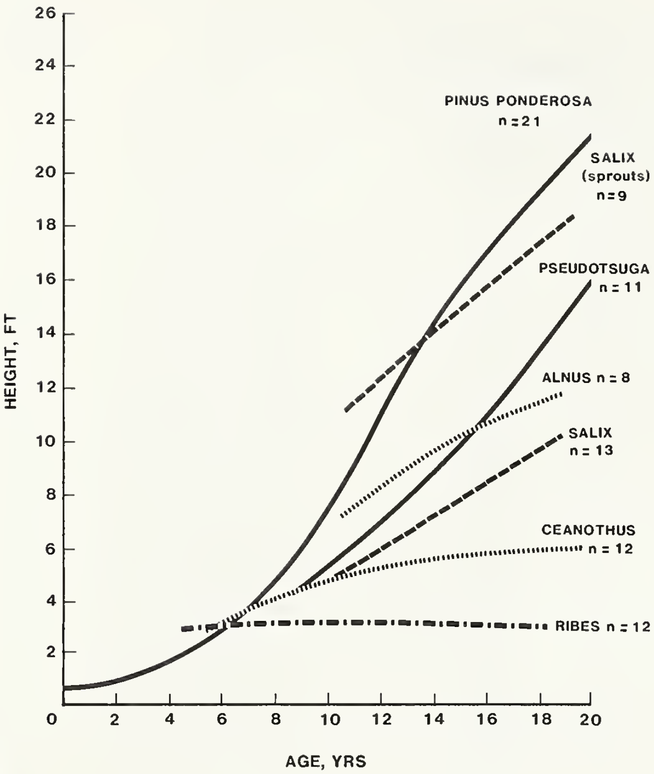

Figure 16—Height-age relationships of free-growing tree seedlings and important shrubs in ABGR/VAGL h.t.

based on *R. viscosissimum; R. lacustre* has a similar curve but is slightly shorter. Seedlings of *Alnus sinuata* might outgrow planted pine, but the entire *Alnus* growth curve was not shown in figure 16 due to insufficient data. Whenever pines are planted after the first growing season following disturbance, shrub seedlings such as *Ceanothus, Salix,* or *Alnus* may outcompete the pines (fig. 17).

Sprouting ability varies among species and also with size and vigor of the individual. Of the major shrubs in ABGR/VAGL, *Salix* has the greatest sprouting ability. Figure 16 suggests that it would take ponderosa pine about 13 years to overtop *Salix* sprouts. If the site in question has a high density of *Salix* and pine is to be planted, deep scarification to remove the *Salix* stumps may be needed to reduce competition. The scarification will encourage *Ribes* and *Salix* from seed (table 10), but properly planted pines can outgrow these seedlings (fig. 16). If the site in question occurs at the moist extreme of ABGR/VAGL, *A. sinuata* may also appear following scarification (tables 9, 10). The growth curve of *Alnus* sprouts in relation to planted pines in ABGR/VAGL is not known; but *Alnus* sprouts, like *Salix* sprouts (fig. 16), will surely outcompete the pine. When severe competition from sprouting *Salix* or *Alnus* is inevitable, either mechanical or chemical treatment will be needed where pine plantations are a management objective. An alternative is to manage for the more shade-tolerant *Pseudotsuga* or *Picea*.

Figure 17—A ponderosa pine plantation lost to shrub competition. This area was clearcut and broadcast burned 18 years ago. *Ceanothus* began developing a shrub layer in response to the burning. After three growing seasons, the site was planted to ponderosa pine. The planted pines could not outgrow the *Ceanothus*, which had a 3-year lead, and are now badly suppressed beneath the dense shrub layer.

The above paragraphs show how components of tables 9 and 10 and figure 16 can be assembled to meet stand-specific conditions. Considerations for each stand may differ but should include:

1. The desired tree species, its shade tolerance and growth rate;
2. The kind and intensity of site treatment needed to favor the desired tree species and reduce existing competition;
3. Existing shrub species and their potential for reacting to the proposed timber harvest and site treatment;
4. Potential reactions of buried seed and windblown seed to the site treatment selected; and
5. Duration of the potential competition in terms of height-age interactions of shrub species and tree seedlings.

This set of interacting variables may seem complex at first but, once learned, provides an ecological basis for prescribed treatments on a stand-specific basis. Until more specific information is available, these variables can be extrapolated to similar habitat types by adjusting for changes in species composition and growth potential. More productive habitat types may support additional shrub species whose successional roles and reproductive strategies will need to be considered. Less productive habitat types may support fewer species (although new species may appear) and may have less complex successions.

Natural Tree Establishment—Naturally established tree seedlings were recorded by species, silvicultural treatment, and microsite conditions. A seedling was defined as a tree less than 4.5 feet (1.4 m) tall and 3 years old or older, but younger than the disturbance. Although a separate study (Geier-Hayes 1985), the natural tree establishment study was conducted concurrently with succession studies of the ABGR/VAGL and grand fir/mountain maple (ABGR/ACGL) h.t.'s.

A total of 242 natural seedlings were recorded in ABGR/VAGL. Of these, 60 percent were *Abies grandis*, 14 percent were *Pseudotsuga*, and 13 percent *Picea*. The average number of seedlings per acre and percentage of total for each species are shown in table 11. A regeneration efficiency (RE) value was computed for each seedling species in each microsite. An RE value of 1.00 indicates that the seedlings occurred on a particular microsite in proportion to the occurrence of the microsite. Values greater than 1.00 are designated very efficient (possibly beneficial), 0.75 to 0.99 moderately efficient (slightly beneficial), 0.25 to 0.74 slightly efficient (beneficial or detrimental), and less than 0.25 inefficient (detrimental). RE values were calculated for the microsite seedbed and canopy cover, if present. In order to strengthen the data base, RE values for canopy cover vegetation were calculated using data from the ABGR/VAGL and ABGR/ACGL h.t.'s. Even though ABGR/VAGL is somewhat cooler than ABGR/ACGL, other environmental conditions of these two habitat types are similar.

Although RE values may reflect a relationship between the microsite and tree seedling, several factors affect interpretation of these values. It was assumed that seedlings persist only in a favorable microsite: one that promotes germination **and** provides the resources for growth and development (Harper 1977). If a seed germinates in a favorable microsite and the microsite deteriorates, such as through rapid shrub development, the seedling should die. Some seedlings may have been recorded in unfavorable microsites such as a microsite which provided the stimulus for germination but cannot provide the resources for continued development. Therefore, some microsites identified as beneficial may in fact preclude development of a mature tree. In this respect, the microsite canopy cover is more influential than the seedbed through time, but the relationship between the microsite canopy cover and seedling was not always easy to determine. In some cases, the tree seedling and canopy cover may have benefited from the same microsite and simply established near one another coincidentally. In other cases, the tree seedling may have benefited from existing cover vegetation, which provided more favorable microsite conditions in terms of light, soil moisture and nutrients, humidity, temperature, and wind protection (Zavitkovski and Woodard 1970).

Table 11—Average number of natural seedlings per acre in ABGR/VAGL h.t.

Seedling species	Number of seedlings counted	Average seedlings per acre	Percentage of total sample
PICO	19	64	7.9
LAOC	1	3	.4
PIPO	13	44	5.4
PSME	33	111	13.6
PIEN	31	104	12.8
ABGR	145	489	60
Total	242	815	100

Figure 18—An example of a seedling microsite. The protection of a burned log, a canopy of *Ceanothus*, and mineral soil having a light litter cover contribute to a favorable microsite for these *Pseudotsuga* seedlings.

Some microsites having cover vegetation may favor one seedling species but not another (fig. 18). A heavy canopy cover may favor shade tolerant tree species but not shade intolerant species, or an allelopathic cover species may preclude establishment of some tree seedlings. Where a positive seedling-microsite relationship exists, the canopy cover species may be used to help establish natural regeneration, or to indicate favorable microsites. Where a negative relationship exists, canopy cover species may be used to indicate unfavorable microsites.

Table 12—Occurrence of natural seedlings (percent) by silvicultural method and percent overstory composition

Silvicultural method	Number of sites sampled[1]	Seedling occurrence, percent[2]					
		PICO	LAOC	PIPO	PSME	PIEN	ABGR
CLEARCUT	60	55	12	10	24	23	11
SEED-TREE CUT	8	28	68	75	43	34	10
Overstory, pct		Seedling occurrence (percent) within seed-tree cuts					
LAOC 3	1	—	52	—	—	—	—
LAOC 3, PIEN 15	1	100	39	—	13	95	69
PIPO 3	3	—	9	9	22	5	19
PIPO 1, ABGR 15	1	—	—	91	65	—	6
ABGR 15[3]	2	—	—	—	—	—	6
SHELTERWOOD CUT	5	—	—	13	3	38	9
Overstory, pct		Seedling occurrence (percent) within shelterwood cuts					
PICO 3, PSME 1, ABGR 3	1	—	—	—	—	—	64
PIPO 3, ABGR 5	1	—	—	100	—	—	—
PSME 15, ABGR 20	2	—	—	—	100	—	27
PSME 15, PIEN 3, ABGR 15	1	—	—	—	—	100	9
SELECTION CUT	13	17	5	—	28	—	11
Overstory, pct		Seedling occurrence (percent) within selection cuts					
LAOC 3, PSME 38, ABGR 15	1	—	100	—	55	—	22
PIPO 3, ABGR 15	1	—	—	—	—	—	—
PIPO 3, PSME 15, ABGR 15	1	100	—	—	—	—	—
PSME 15	1	—	—	—	14	—	7
PSME 3, PIEN 1, ABGR 38	1	—	—	—	—	—	19
PSME 12, ABGR 5	5	—	—	—	14	—	7
PIEN 15, ABGR 63	1	—	—	—	—	—	4
ABGR 39	2	—	—	—	17	—	41
STAND-DESTROYING WILDFIRE	8	—	15	2	2	5	59
Overstory, pct		Seedling occurrence (percent) within wildfires					
No tree cover	2	—	—	—	100	—	3
LAOC 3, ABGR 3	1	—	100	—	—	100	40
PIPO 15, ABGR 15	2	—	—	100	—	—	1
PSME 20	2	—	—	—	—	—	3
ABGR 3	1	—	—	—	—	—	52

[1]Each site contained five sampled microplots.
[2]Percent occurrence of tree seedlings includes the following seedlings from ABGR/ACGL h.t.: 4 PICO, 24 LAOC, 67 PIPO, 114 PSME, 21 PIEN, 185 ABGR.
[3]Not all sample sites were categorized herein as the land manager intended; in this case, two clearcuts had scattered mature *Abies* left standing, creating an *Abies* seed-tree effect.

Pinus contorta seedlings established over a period that ranged from 0 (growing season immediately following the disturbance) to about 20 years (for a 30-year sample period). The average number of years from disturbance to germination was 6. Data from ABGR/VAGL and ABGR/ACGL indicate that *P. contorta* regeneration is highest (55 percent) on clearcut units (table 12). In these clearcuts, most seedlings (75 percent) occurred on sites that had been scarified either for planting or from slash disposal (table 13). Fewer (25 percent) occurred on sites that had received little or no site preparation; however, none were found on residual duff (table 14). Bare mineral soil and moss mat seedbeds both had very efficient RE values for *P. contorta*; litter-covered scarified soil was slightly efficient (table 14). *Polytrichum juniperinum* was the moss most commonly found with conifer seedlings. It usually occurred on scarified soils. The largest proportion (52 percent) of *P. contorta* seedlings was found on sites with moderate (33 to 66 percent) canopy cover (table 15). The canopies of *Spiraea betulifolia, Lonicera utahensis,* and

Table 13—Occurrence of natural seedlings (percent) by site preparation method for ABGR/VAGL h.t.

Species	Site preparation			
	None	Broadcast burn	Scarification: Light	Scarification: Heavy
	Percent			
PICO	25	—	66	9
LAOC[1]	4	14	82	—
PIPO	22	—	39	39
PSME	9	—	73	18
PIEN	29	11	52	8
ABGR	13	14	52	21
	Number			
Microplots	16	11	78	15

[1]Values for *Larix occidentalis* are from ABGR/VAGL and ABGR/ACGL h.t.'s.

Table 14—Occurrence of natural seedlings (percent) and regeneration efficiencies (RE) for seedbeds in ABGR/VAGL h.t.

	Seedbed											
Species	Litter-covered scarified soil		Bare mineral soil		Moss mat		Rotten wood		Residual duff		Rocks or stumps	
	Pct	*RE*[1]	*Pct*	*RE*	*Pct*	*RE*	*Pct*	*RE*	*Pct*	*RE*	*Pct*	*RE*
PICO	39	0.59	39	2.60	23	1.77	—	—	—	—	—	—
LAOC[2]	32	.46	11	.58	58	8.29	—	—	—	—	—	—
PIPO	46	.70	31	2.07	15	1.15	8	2.67	—	—	—	—
PSME	55	.83	18	1.20	21	1.62	6	2.00	—	—	—	—
PIEN	37	.56	—	—	50	3.85	3	1.00	10	5.00	—	—
ABGR	35	.53	7	.47	15	1.15	14	4.67	28	14.00	—	—
Seedbed occurrence[3]	66		15		13		3		2		1	
Seedbeds with seedlings[4]	29		26		29		6		10		0	

[1]Regeneration efficiency (RE) is the percent occurrence of a seedling species divided by percent area occupied by the seedbed.
[2]Values for *Larix occidentalis* are from ABGR/VAGL and ABGR/ACGL h.t.'s.
[3]Seedbed occurrence is the percent occurrence of a certain seedbed in all 120 microplots.
[4]Seedbeds with seedlings is the percent of microplots with seedlings on a certain seedbed.

Table 15—Occurrence of natural seedlings (percent) by shrub canopy cover for ABGR/VAGL h.t.

	Shrub canopy cover		
Species	Light (0-33%)	Moderate (33-66%)	Heavy (66-100%)
		Percent	
PICO	14	52	35
LAOC[1]	53	41	7
PIPO	40	34	26
PSME	49	17	35
PIEN	25	34	41
ABGR	18	33	49
		Number	
Microplots	30	44	46

[1]Values for *Larix occidentalis* are from ABGR/VAGL and ABGR/ACGL h.t.'s.

Abies grandis had very efficient RE values. *Ribes* spp., *Vaccinium globulare*, and *Rubus parviflorus* RE values were slightly efficient; forbs and *Salix scouleriana* were inefficient for *P. contorta* (table 16). Seedling occurrence was also summarized by tree and shrub layer groups. In terms of tree layer, most *P. contorta* seedlings (59 percent) occurred beneath the PICO l.g., followed by the PSME (29 percent), LAOC (7 percent), and PIPO (5 percent) l.g.'s (table 17). The relative nature of these values apparently reflects the importance of an on-site *P. contorta* seed source for adequate regeneration. In terms of shrub layer, most *P. contorta* seedlings occurred in the VAGL, SASC, and ALSI l.g.'s (30 percent each), followed by the CEVE (6 percent), RIVI (2 percent), and SPBE (2 percent) l.g.'s (table 17). Due to the shallow root system of *Vaccinium*, the VAGL l.g. can endure only light scarification whereas the CEVE and RIVI l.g.'s can result from heavy scarification. These relationships coincide with the

Table 16—Occurrence of natural seedlings (percent) and regeneration efficiencies (RE) by shrub canopies and other microsites[1]

Canopy	Canopy constancy	Area occupied	PICO		LAOC		PIPO		PSME		PIEN		ABGR	
	- - - - - *Percent* - - - - -		*Pct*	*RE*[2]	*Pct*	*RE*	*Pct*	*RE*	*Pct*	*RE*	*Pct*	*RE*	*Pct*	*RE*
None	—	—	3	—	5	—	4	—	3	—	4	—	6	—
Forbs only	99.6	18.3	2	0.11	—	—	1	.07	4	0.21	2	0.10	2	0.11
Graminoids	90.0	7.2	—	—	—	—	—	—	10	[3]1.33	—	—	2	[3].31
Slash	56.8	4.1	—	—	5	1.15	2	.44	3	.71	2	.46	5	1.12
Ribes spp.	46.8	4.8	3	.56	20	4.17	3	.54	3	.56	3	.67	3	.52
Salix scouleriana	36.8	10.4	2	.19	1	.12	3	.29	2	.18	2	.16	4	.40
Spiraea betulifolia	32.8	2.6	7	2.85	—	—	10	4.00	3	.96	1	.31	3	1.27
Vaccinium globulare	31.7	7.5	4	.55	7	.95	6	.77	5	.71	2	.31	4	.48
Ceanothus velutinus	31.1	10.6	—	—	4	.33	3	.25	4	.39	—	—	4	.39
Lonicera utahensis	30.2	3.6	6	1.69	11	2.94	2	.61	4	1.00	5	1.33	2	.53
Rubus parviflorus	24.0	3.5	2	.57	—	—	13	3.69	3	.89	3	.97	2	.49
Rosa spp.	22.3	.6	—	—	—	—	7	12.00	1	2.17	—	—	2	3.17
Physocarpus malvaceus	19.8	3.8	—	—	8	2.16	1	.37	3	.68	1	.16	3	.89
Pinus ponderosa	19.1	4.5	—	—	—	—	2	.49	4	.80	1	.13	3	.71
Abies grandis	14.0	4.0	37	9.30	11	2.65	—	—	2	.43	3	.80	6	1.55
Pseudotsuga menziesii	12.6	1.8	—	—	—	—	—	—	2	.89	—	—	6	3.22
Acer glabrum	12.3	2.6	—	—	—	—	3	1.15	3	1.15	—	—	4	1.58
Symphoricarpos spp.	7.9	1.7	—	—	—	—	—	—	—	—	—	—	—	—
Prunus spp.	7.0	1.4	—	—	—	—	—	—	9	6.07	5	3.79	4	2.79
Alnus sinuata	6.8	3.1	—	—	—	—	—	—	1	.35	14	4.55	3	.97
Pachistima myrsinites	5.1	.6	—	—	29	[3]49.00	—	—	5	[3]8.00	—	—	1	[3]1.83
Amelanchier alnifolia	4.5	.6	—	—	—	—	20	[3]33.17	—	—	—	—	—	—
Sorbus scopulina	3.2	.6	—	—	—	—	—	—	19	[3]32.00	11	[3]17.50	—	—
Picea engelmannii	2.8	.2	—	—	—	—	—	—	—	—	42	[3]210.00	—	—
Sambucus racemosa	2.3	.2	—	—	—	—	—	—	—	—	—	—	5	[3]22.50
Pinus contorta	2.1	.5	—	—	—	—	—	—	—	—	—	—	2	[3]4.40
Larix occidentalis	1.9	.5	—	—	—	—	—	—	10	[3]19.20	—	—	—	—
Shepherdia canadensis	1.9	.4	—	—	—	—	—	—	—	—	—	—	18	[3]44.50
Populus tremuloides	1.9	.1	34	[3]338.00	—	—	—	—	—	—	—	—	2	[3]228.00

[1]This table includes the following seedlings from ABGR/ACGL h.t.: 4 PICO, 24 LAOC, 67 PIPO, 114 PSME, 21 PIEN, 185 ABGR.
[2]Regeneration efficiency (RE) is the percent occurrence of a seedling species divided by percent area occupied by the seedbed.
[3]Discretionary values: large values due to small sample size.

Table 17—Occurrence of natural tree seedlings (percent) by tree and shrub layer groups in ABGR/VAGL h.t.

Layer group	Number of samples	Seedling species				
		PICO	PIPO	PSME	PIEN	ABGR
		Percent				
TREE LAYER GROUPS						
PICO	3	59	—	28	23	8
LAOC	2	7	—	25	17	70
PIPO	13	5	100	25	9	14
PSME	1	29	—	—	51	3
PIEN	1	—	—	—	—	3
ABGR	1	—	—	—	—	—
depauperate	3	—	—	22	—	3
SHRUB LAYER GROUPS[1]						
CEVE	5	6	31	28	12	21
RIVI	8	2	39	44	6	24
SASC	7	30	30	20	10	48
ALSI	2	30	—	—	50	5
SPBE	7	2	—	8	6	1
LOUT	2	—	—	—	17	2
VAGL	1	30	—	—	—	—
		Number				
Tree seedlings sampled under shrubs		20	13	36	36	145

[1]Shrub layer groups include eight plots not used in previous data analysis. These plots were obtained using an older sampling procedure (see methods) and were used to supplement layer groups for which little or no data had been obtained using the new sampling method.

much higher occurrence of *P. contorta* seedlings on lightly scarified areas than on heavily scarified areas (table 13).

The sample data suggest that the best silvicultural and site preparation method for *P. contorta* is clearcutting with light scarification. These data agree with those of previous studies (Boe 1956; Cochran 1953; Dahms 1963; Day and Duffy 1963; Tackle 1956; Trappe 1959). In most cases, if *P. contorta* slash is distributed over the scarified soil such that the cones lie on or just above the soil, soil surface temperatures will be adequate to open serotinous cones (Lotan 1964). But the amount of cone serotiny is relatively low. Light scarification treatments that maintain the VAGL l.g. or promote development of the SASC l.g. are the most effective. Although *Salix* is an inefficient RE species for *P. contorta*, occurrence of *P. contorta* seedlings is high in the SASC l.g., possibly due to other higher RE value species or the fact that light scarification favors seedlings of both *Salix* and *P. contorta*. If the treated stand has high initial coverage of *Salix*, the extensive canopy cover that may occur from sprouts of *Salix* following clearcutting will likely inhibit *P. contorta* establishment and growth. Broadcast burns that produce the CEVE l.g. may promote establishment of *P. contorta* seedlings provided a seed crop exists at the time of burning; however, extremely hot broadcast burns that produce a dense cover of *Ceanothus* may preclude establishment of *P. contorta* in future years.

Larix occidentalis seedlings were scarce in the ABGR/VAGL h.t.; only one seedling occurred in the sample plots. Data from the ABGR/ACGL h.t. showed that *Larix* germination ranged from 0 to 14 years following disturbance, with an average of 1 year. Most seedlings (68 percent) occurred in seed-tree cutting units, and 91 percent of those seedlings occurred on sites with *Larix* seed-trees (table 12). Considerably fewer seedlings (12 percent) were found in clearcuts, while 5 percent were found in the only selection cut stand that had *Larix* as an overstory component. A small portion of the sample stands had been disturbed by wildfire, and 15 percent of the *Larix* seedlings occurred in one such stand. The disturbance in these wildfire stands, however, was much older than the sampled silvicultural treatments, and the large occurrence of seedlings may be due to a longer developmental period rather than type of disturbance. In terms of site preparation, most seedlings (82 percent) occurred on sites that had been lightly scarified (table 13). Only moss mats had a very efficient RE value for *Larix* (table 14). Bare mineral soil and litter-covered scarified soils were both slightly efficient. The largest proportion of seedlings (53 percent) was found on sites with a light shrub canopy cover (table 15). Logging slash, *Ribes* spp., *Lonicera utahensis*, *Physocarpus malvaceus*, and *Abies grandis* all had very efficient RE values for *Larix* (table 16); *Vaccinium globulare* was moderately efficient, *Ceanothus velutinus* was slightly efficient, and *Salix scouleriana* was inefficient.

Seed-tree cuts with *Larix* seed-trees and light scarification (Boyd and Deitschman 1969; Haig and others 1941; Schmidt 1969) will likely promote establishment of natural *Larix* regeneration. Even though only one seedling was found in ABGR/VAGL, data from ABGR/ACGL indicate that canopies of *Ribes, Lonicera,* and *Vaccinium* may enhance establishment of *Larix*. Therefore site treatments such as light scarification, which favor these shrub species, may also enhance establishment of *Larix* seedlings.

Pinus ponderosa germination averaged about 6 years and ranged from 0 to 19 years following disturbance. Most

of the regeneration (75 percent) was found on seed-tree cutting units. All of the seedlings occurred on sites having a *P. ponderosa* seed source nearby (table 12). No natural regeneration was found in partially cut stands even though two stands had *P. ponderosa* in the overstory. Scarification treatments produced most of the natural regeneration (78 percent) (table 13). Very efficient RE values were found for rotten wood, bare mineral soil, and moss mat seedbeds (table 14). Litter-covered scarified soil was found to be slightly efficient. Rotten wood from logs and stumps was found both on sites with and without site preparation. On areas with site preparation, scarification most often occurred around intact logs or stumps, which then decayed in place. This is in contrast to a few sites on which already decayed logs or stumps were incorporated into mineral soil during scarification. Overall, scarification treatments resulted in more natural regeneration of all species probably by reducing the coverage of residual duff; but when rotten wood is present, it may provide a more beneficial rooting environment than mineral soil (Harvey 1982). Nevertheless, manipulating logs and stumps to increase natural regeneration is not a practical management option.

Many *P. ponderosa* seedlings occurred beneath some shade. Forty percent were found under a light shrub canopy cover; 34 percent occurred under moderate cover and 26 percent under heavy canopy cover, respectively (table 15). Canopies of *Rubus parviflorus, Spiraea betulifolia, Rosa* spp., and *Acer glabrum* had very efficient RE values (table 16). *Vaccinium globulare* was moderately efficient, and several species were slightly efficient. In terms of tree canopy all natural regeneration was found in the PIPO l.g. (table 17). In terms of shrub canopy, *P. ponderosa* seedling occurrence was highest in the RIVI l.g. (39 percent) and slightly lower in the CEVE (31 percent) and SASC (30 percent) l.g.'s. All three of these layer groups often result from thorough scarification.

On some sites, seed caches may play an important role in *P. ponderosa* establishment. In the Oregon Cascade Range, West (1968) found that 15 percent of the *P. ponderosa* seedlings resulted from rodent caches. In central Idaho, McConkie and Mowat (1936) found that a similar proportion (14 percent) of seedlings resulted from caches. Medin (1984) indicated that the yellowpine chipmunk (*Eutamias amoenus*) may be responsible for many of the caches found in central Idaho, although the Clark's nutcracker (*Nucifraga columbiana*) may also be involved (Lanner 1980). In ABGR/VAGL, 17 percent of the *P. ponderosa* regeneration apparently established from seed caches. The incidence of seed caches was highest on sites with *R. parviflorus*, and the number of caches increased as the coverage of *Rubus* increased. This may have resulted from increased rodent activity where the *Rubus* occurs because chipmunks feed on *Rubus* berries (Martin and others 1951; Van Horne 1982), or because the *Rubus* provides cover for the chipmunks.

Pinus ponderosa seed-tree cuts (Foiles and Curtis 1973; Heidmann and others 1982) followed by scarification (Baker 1942; Harrington and Kelsey 1979; Shearer and Schmidt 1970) are the most favorable condition for establishment of natural *P. ponderosa* seedlings. The most effective site treatment is one which promotes establishment of the RIVI l.g. and provides some cover of *Spiraea* and *Rubus*. Broadcast burns which produce the CEVE l.g. may encourage natural *P. ponderosa* establishment provided a seed crop exists at the time of burning. Broadcast burns which produce a dense *Ceanothus* cover may preclude pine establishment from subsequent seed crops.

Pseudotsuga menziesii germination occurred from 0 to 21 years following disturbance and averaged about 6 years. Most of the regeneration (43 percent) was found on seed-tree cutting units; however, none of these sites contained *Pseudotsuga* seed-trees (table 12). Twenty-eight percent of the seedlings established in partially cut stands where 83 percent of the seedlings occurred in stands with *Pseudotsuga* in the overstory. Scarification treatments produced the most regeneration (91 percent) (table 13). Rotten wood, moss mats, and bare mineral soil seedbeds had very efficient RE values for *Pseudotsuga* (table 14). Litter-covered scarified soil was moderately efficient. Most seedlings (49 percent) were found under a light shrub canopy; 17 percent occurred under a moderate canopy cover and 35 percent under a heavy canopy (table 15). Very efficient RE values occurred for *Lonicera utahensis, Rosa* spp., *Prunus* spp., and *Acer glabrum* (table 16). *Spiraea betulifolia, Rubus parviflorus, Pinus ponderosa,* and *P. menziesii* were moderately efficient and slash, *Ribes* spp., *Vaccinium globulare, Ceanothus velutinus, Physocarpus malvaceus, Abies grandis,* and *Alnus sinuata* were slightly efficient. *Salix scouleriana* had an inefficient RE value. In terms of tree layer succession, most *Pseudotsuga* seedlings (28 percent) were found in the PICO l.g. although occurrences were only slightly lower in the LAOC (25 percent), PIPO (25 percent), and depauperate (22 percent) l.g.'s (table 17). In terms of shrub layer succession, *Pseudotsuga* regeneration was highest (44 percent) in the RIVI l.g. Twenty-eight percent occurred in the CEVE l.g. and 20 percent occurred in the SASC l.g.

The sample data suggest that optimum conditions for natural regeneration of *Pseudotsuga* would be either a seed-tree cut (Williamson 1973) with at least 16 percent tree canopy cover, and a *Pseudotsuga* seed source nearby, or a selection cut in the LAOC or PICO tree layer group with *Pseudotsuga* in the overstory. Thorough scarification which produces an RIVI l.g. will likely provide the best microsite for seedling establishment. The best seedbeds were bare soil and scarified soil covered with a moss mat. Broadcast burns that produce the CEVE l.g. with light or moderate coverages of *Ceanothus* may facilitate *Pseudotsuga* regeneration.

Picea engelmannii germinated over a period of 0 to 22 years following disturbance; the average was about 6 years. Regeneration was highest (38 percent) in a single shelterwood cut, which was the only sampled shelterwood having *Picea* in the overstory (table 12). Regeneration on seed-tree cutting units was slightly lower (34 percent). In this case, 95 percent of the seedlings established in a stand having *Picea* and *Larix* seed-trees, with a combined canopy cover of about 18 percent. Some seedlings (23 percent) were also found in clearcuts. Many of the seedlings (60 percent) occurred on scarified sites (table 13). The rest of the seedlings were found on sites that had been broadcast burned (11 percent) or had no site preparation (29 percent). Residual duff, rotten wood, and moss-mat

seedbeds had very efficient RE values (table 14). Litter-covered scarified soil was slightly efficient. The largest proportion of seedlings (41 percent) was found on sites with heavy canopy cover, but the occurrence of seedlings decreased only slightly with decreasing canopy cover (table 15). *Lonicera utahensis*, *Prunus* spp., and *Alnus sinuata* had very efficient RE values (table 16). Moderately efficient RE values were found for *Rubus parviflorus* and *Abies grandis*. Slash, *Ribes* spp., *Spiraea betulifolia*, and *Vaccinium globulare* were slightly efficient. Inefficient RE values occurred for forbs, *Salix scouleriana*, *Physocarpus malvaceus*, and *Pinus ponderosa*. Most of the regeneration (51 percent) was found in the PSME l.g. (table 17). The rest of the regeneration occurred in the PICO (23 percent), LAOC (17 percent), and PIPO (9 percent) l.g.'s. In terms of shrub layer succession, more *Picea* seedlings were found in the ALSI l.g. (50 percent) than in the LOUT (17 percent), CEVE (12 percent), SASC (10 percent), or RIVI (6 percent) l.g.'s.

Shelterwood cuts (Day 1963, 1964; Day and Duffy 1963; Roe and others 1970) in a PSME or PICO tree layer type containing *Picea*, or seed-tree cuts having *Picea* in the overstory and at least 18 percent canopy cover, should provide an adequate tree canopy for *Picea* regeneration. Scarification will likely create the best seedbed for obtaining *Picea* regeneration (Bernsten 1955; Boyd and Deitschman 1969; Fiedler and others 1985; Roe and others 1970). As with the other previously mentioned species, scarification enhances *Picea* establishment; however, *Picea* also establishes on residual duff. A combination of heavy canopy cover and residual duff may favor *Picea* and may preclude other tree regeneration except *A. grandis*. Scarification treatments that result in, or maintain, the LOUT or ALSI l.g.'s and retain some residual duff should provide favorable microsites. Hot broadcast burns that produce a heavy canopy cover of *Ceanothus* may encourage establishment of *Picea* over other species.

Abies grandis germination ranged from 0 to 30 years following disturbance, averaging about 7 years. Most seedlings (59 percent) occurred in two old wildfire-disturbed stands; there was little difference between occurrence of seedlings among the artificially disturbed stands (table 12). Selection cut stands and clearcuts contained 11 percent of the seedlings; seed-tree cuts had 10 percent, and shelterwood cuts had 9 percent. In terms of site treatment, most seedlings (73 percent) occurred on scarified sites (table 13). In contrast, fewer seedlings were found in broadcast burned (14 percent) and no site preparation (13 percent) areas. Very efficient RE values were found for residual duff, rotten wood, and moss mats (table 14). Most seedlings (49 percent) occurred under heavy canopy cover (table 15). Seedling occurrence decreased with decreasing canopy cover; only 18 percent of the seedlings were found under light cover. Very efficient RE values occurred for slash, *Spiraea betulifolia*, *Rosa* spp., *Abies grandis*, *Pseudotsuga menziesii*, *Prunus* spp., and *Acer glabrum* (table 16). *Physocarpus malvaceus* and *Alnus sinuata* were moderately efficient. Slightly efficient values were found for *Ribes* spp., *Salix scouleriana*, *Vaccinium globulare*, *Lonicera utahensis*, *Rubus parviflorus*, and *Pinus ponderosa*. In terms of tree cover, most of the seedlings (70 percent) established in one stand in the LAOC l.g. (table 17). Fewer were found in the PIPO (14 percent) and PICO (8 percent) l.g.'s. The PSME and PIEN l.g.'s each contained only 3 percent. In terms of shrub layer, the SASC l.g. contained the most *A. grandis* seedlings (48 percent). The remaining seedlings established in the RIVI (24 percent), CEVE (21 percent), ALSI (5 percent), LOUT (2 percent), and SPBE (1 percent) l.g.'s (table 17).

Almost any silvicultural method can be used to regenerate *A. grandis*. Scarification, especially, will enhance *A. grandis* seedling establishment (Haig and others 1941). As with *Picea*, *A. grandis* also establishes on residual duff. A combination of heavy canopy cover and residual duff will likely result in more *A. grandis* regeneration than that of other species except *Picea*. Site treatments that favor the CEVE, RIVI, or SASC l.g.'s are most apt to produce *A. grandis* seedlings.

SUMMARY OF SHRUB LAYER SECTION

Shrub layer classification in ABGR/VAGL consists of seven layer groups and 28 layer types. The classification is based on seven indicator species and three alternates.

Ceanothus velutinus indicates early seral conditions. Seed stored in the soil remains viable for centuries and germinates when it is heated by fire. The species is widespread in ABGR/VAGL, and its absence following severe burning may indicate either wet sites suitable for *Picea* or frost pockets better suited for *Pinus contorta* than *P. ponderosa*. *Ceanothus* serves as an indicator of seven layer types. Six of these result from either wildfire or different intensities of burning following clearcutting or from scarification. One layer type, CEVE-RIVI, results mainly from severe scarification. All seven depend somewhat on composition of the predisturbance shrub layer as well as disturbance intensity.

Ribes viscosissimum and *R. lacustre* also indicate early seral shrub layers and also store seed in the soil. The buried seed germinates readily following clearcutting and scarification without burning. *Ribes lacustre* occurs mainly on the wetter sites suitable for *Picea*. *Ribes* serves as an indicator of six layer types, which result mainly from different intensities of scarification in different predisturbance shrub layers. Thorough scarification most often results in the RIVI-RIVI layer type, which creates the least competition for planted trees over time of any shrub layer in ABGR/VAGL.

Salix scouleriana acts as a midseral species in ABGR/VAGL and can resprout vigorously following clearcutting. Its windblown seed is most apt to establish on well-scarified soil, especially along contour ditches or terraces. In clearcuts, properly planted *Pinus ponderosa* can usually overtop *Salix* seedlings, but are severely outcompeted by *Salix* that resprouts from residual stumps. High densities of *Salix* in uncut stands may preclude success of pine plantations following clearcutting.

Alnus sinuata acts as a midseral species in ABGR/VAGL and occurs mainly on the wetter sites, which are often suitable for *Picea*. The *Alnus* establishes following clearcutting or wildfire on moist mineral soil and can resprout from stumps. The stump sprouts and possibly seedlings may outcompete planted pines.

Spiraea betulifolia and the alternate indicators *Symphoricarpos albus* and *Rubus parviflorus* are rhizomatous late seral shrubs that are seldom eradicated during scarification. Some SPBE layer types may result from clearcutting and scarification without burning. All three layer types can result from uninterrupted succession.

Lonicera utahensis is an indicator of late seral conditions and often survives logging and site preparation treatments by resprouting from residual root crowns. Apparently its seed is not stored in the soil.

Vaccinium globulare is a climax species in ABGR/VAGL. This shallow-rooted, rhizomatous shrub is easily removed by scarification. This *Vaccinium* has high forage value for deer, elk, and bear.

Shrub layer types vary considerably in their forage value for deer, elk, and bear. Most early seral CEVE layer types have at least moderate forage value for deer and elk but considerably less for bear. The midseral SASC-VAGL and ALSI-VAGL layer types have the greatest forage value for bear. Shrub forage values are low to moderate for sheep and low for cattle throughout ABGR/VAGL succession.

Natural *Pinus contorta* seedlings should be successful in lightly scarified clearcuts having a seed source nearby. A shrub canopy of *Spiraea* might benefit *P. contorta* seedlings; *Salix* and forbs are apt to be detrimental.

Larix is most apt to regenerate from seed-tree cuts and light scarification. A 3 percent canopy cover of *Larix* should provide an adequate seed source. The shrub canopies of *Ribes* and *Lonicera* may enhance *Larix* establishment.

Natural *Pinus ponderosa* should regenerate best from a seed-tree cut and thorough scarification. A 3 percent canopy cover of *P. ponderosa* should provide an adequate seed source in ABGR/VAGL. The shrub canopies of *Rubus, Rosa,* and *Spiraea* may benefit the pine seedlings; *Ceanothus, Salix,* and forbs may be detrimental. On some sites the seed caches of chipmunks and the Clark's nutcracker may be important to pine establishment.

Pseudotsuga is most apt to regenerate in the partial shade of a tree canopy with a seed source nearby. At least 16 percent tree canopy should be an adequate cover for *Pseudotsuga*. Well-scarified soil or scarified soil that has acquired a moss mat appears to be the best seedbed. The shrub canopies of *Prunus, Rosa, Acer,* and *Lonicera* may facilitate *Pseudotsuga* establishment.

Picea should regenerate best in the partial shade of a tree canopy; at least 18 percent cover should be adequate. Scarified soil that has acquired a moss layer is the best seedbed. *Alnus, Prunus, Lonicera,* and *Rubus* may benefit *Picea* seedlings; *Salix* and forbs may be detrimental.

Abies grandis seedlings appear to have less specific microsite requirements than the other tree species. Scarified soil, rotten wood, and residual duff are all adequate seedbeds. Most seedlings establish under a heavy shrub canopy. The canopies of *Rosa, Prunus,* and *Spiraea* may provide added benefit.

The Herb Layer

The herb layer is more complex and less understood than the tree and shrub layers. Modal conditions of seral stages are evident but more variable because there are more species. More species imply potentially more herb layer types, but the relative increase has been less than expected. It is possible that more kinds of disturbance are needed to generate the broad array of layer types. Still, the following herb layer classification appears to follow logical successional sequences even though it may eventually need more refinement than the tree or shrub layer classifications.

Relative successional amplitudes of important herb layer species (fig. 19) were derived by developing hypotheses for each species followed by testing through many field observations as well as data analysis. Because succession in the herb layer progresses more rapidly than the tree or shrub layer, successional amplitudes for some herb layer species can also be derived from the permanent plot records of Stickney (1980, 1985). As in the tree and shrub layer, successional amplitudes of herb layer species are meaningful only in a relative sense, and the greatest accuracy lies with those amplitudes that are farthest apart. For instance, species indicating the Annuals layer group clearly have less amplitude than *Thalictrum* (fig. 19). But there is less certainty to the relative amplitudes of adjacent species such as *Fragaria* and *Carex geyeri.*

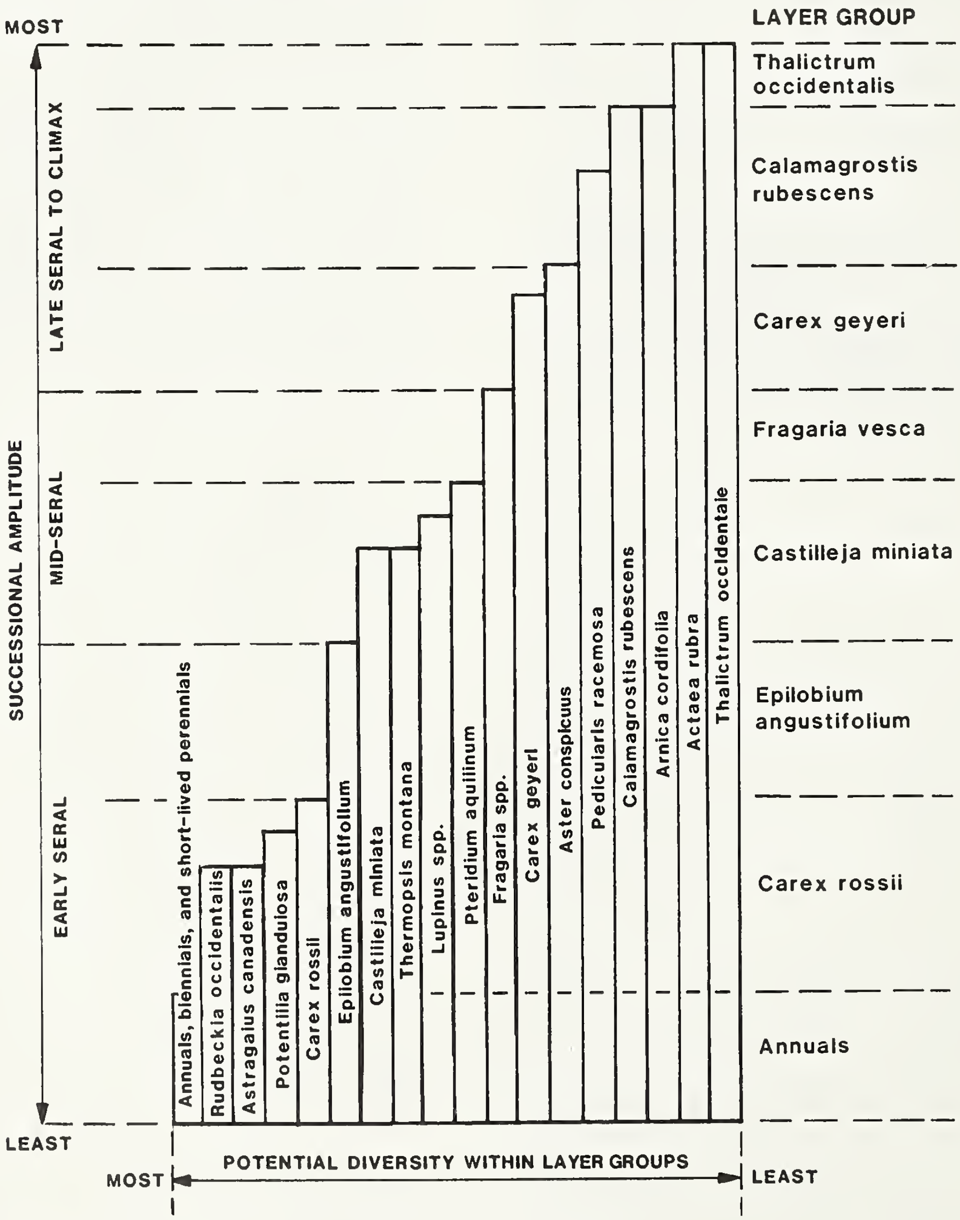

Figure 19—Relative successional amplitudes of important herb layer species in ABGR/VAGL h.t.

Figure 19 lists only the important species, which were those that showed greater than 5 percent coverage somewhere in the data. Many unlisted species may be present in lesser amounts, and some potentially important species may yet be found. Appendix C shows that species diversity may be highest in early seral stages (as figure 19 indicates), but total herb layer coverages may be greatest in midseral to late seral stages, a feature noted previously in a similar study (Hann 1982).

The relative successional amplitudes in figure 19 provide a basis for the present herb layer classification (fig. 20). This classification consists of eight layer groups; the full data set appears in appendix C. Although the classification is based on 64 sample plots, some layer groups have little data. Data in the Annuals layer group are lacking because these conditions usually occur within 5 years following disturbance, and recently disturbed sites were not a sampling objective. Other layer types may be found with more reconnaissance, may appear only after uncommon disturbances, or may be rare under any circumstance.

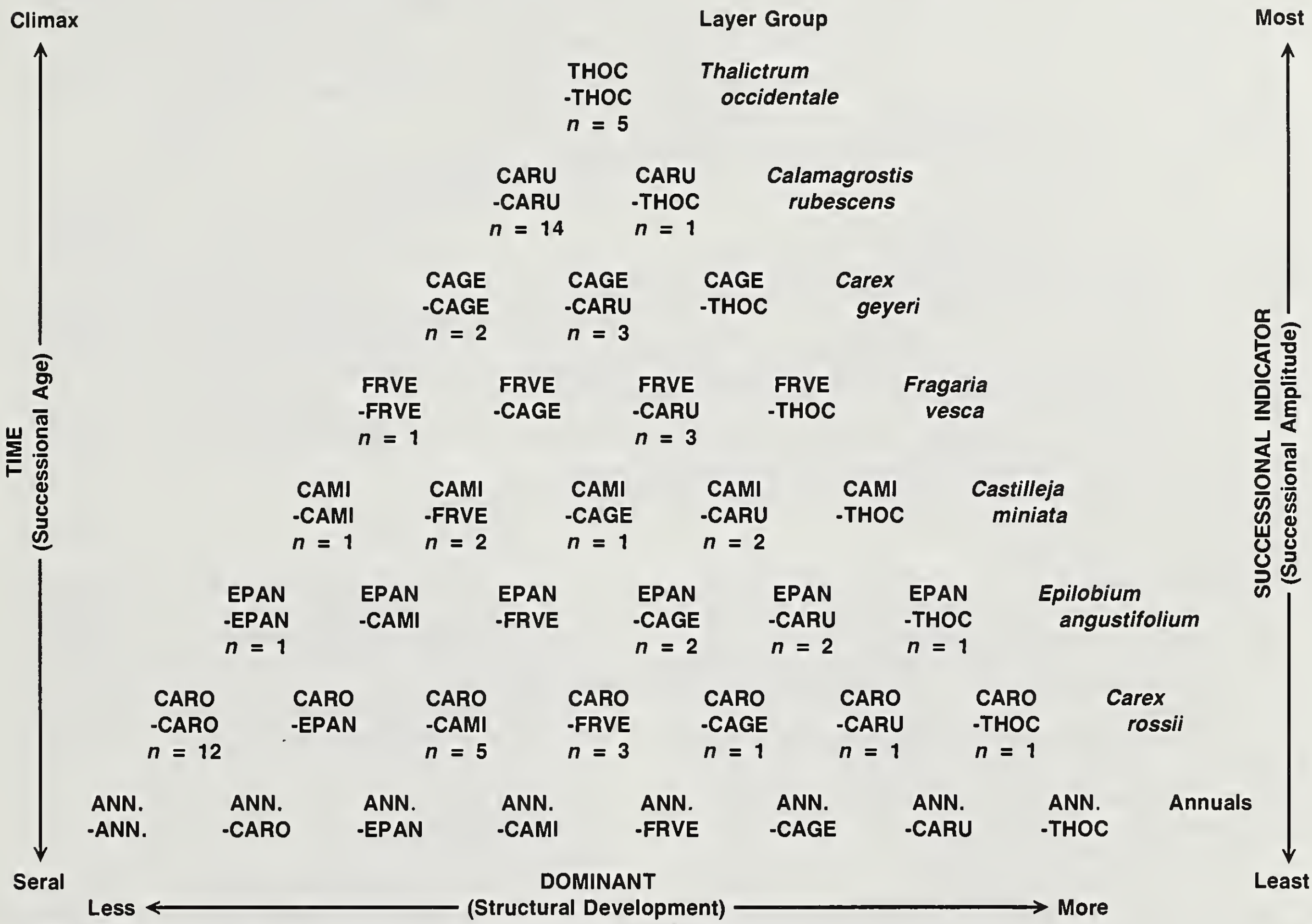

Figure 20—Succession classification diagram of the herb layer in the ABGR/VAGL h.t. (n = number of samples in each layer type).

The key to herb layer types (table 18) contains numerous alternate indicator species. Much of this lumping is necessary to maintain a workable number of units in this diverse vegetative layer. In some cases, combining indicator species has reduced uniformity within the unit because the species represent minor differences of environment or successional pattern within the habitat type. In other cases, the alternate indicators are common environmental and successional equivalents and the classified unit retains substantial uniformity. In all cases the lumped species appear to have similar successional amplitudes (fig. 19).

Early seral annuals, biennials, and short-lived perennials were grouped into one unit because there appears to be no practical reason to recognize them individually. *Rudbeckia*, *Potentilla glandulosa*, and *Astragalus canadensis* were grouped with *Carex rossii* because of similar responses to scarification. *Lupinus* spp. and *Thermopsis montana* were grouped with *Castilleja miniata* due to similar responses to livestock grazing. *Pteridium* occurred in only one sample plot and was subjectively grouped with *Castilleja*. *Carex geyeri* and *Aster conspicuus* were combined as late seral indicators; *Arnica cordifolia* and *Pedicularis racemosa* were grouped with *Calamagrostis rubescens* as near-climax indicators. *Actaea rubra* was grouped with *Thalictrum* as a climax associate.

Table 18—Key to herb layer groups and layer types, with ADP codes, in ABGR/VAGL h.t.

		ADP codes
1. Annuals, biennials, and short-lived perennials (see layer group description for species) well represented[1] either individually or collectively (Choose first condition that fits)	Annuals Layer Group	900
1a. The above species dominant	ANN.-ANN. Layer Type	900.900
1b. *Carex rossii* (incl. *Potentilla glandulosa*, *Astragalus canadensis*, *Iliamna*, and *Rudbeckia*) dominant or codominant	ANN.-CARO Layer Type	900.311
1c. *Epilobium angustifolium* dominant or codominant	ANN.-EPAN Layer Type	900.459
1d. *Castilleja* spp. (incl. *Thermopsis*, *Lupinus*, and *Pteridium*) dominant or codominant	ANN.-CAMI Layer Type	900.438
1e. *Fragaria* spp. dominant or codominant	ANN.-FRVE Layer Type	900.465
1f. *Carex geyeri* (incl. *Aster conspicuus*) dominant or codominant	ANN.-CAGE Layer Type	900.309
1g. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*, dominant or codominant	ANN.-CARU Layer Type	900.307
1h. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	ANN.-THOC Layer Type	900.547
1. Annuals, biennials, and short-lived perennials poorly represented	2	
2. *Carex rossii* (incl. *Potentilla glandulosa*, *Astragalus canadensis*, *Iliamna*, and *Rudbeckia*) well represented (Choose first condition that fits)	CARO Layer Group	311
2a. The above species dominant	CARO-CARO Layer Type	311.311
2b. *Epilobium angustifolium* dominant or codominant	CARO-EPAN Layer Type	311.459
2c. *Castilleja* spp. (incl. *Thermopsis*, *Lupinus*, and *Pteridium*) dominant or codominant	CARO-CAMI Layer Type	311.438
2d. *Fragaria* spp. dominant or codominant	CARO-FRVE Layer Type	311.465
2e. *Carex geyeri* (incl. *Aster conspicuus*) dominant or codominant	CARO-CAGE Layer Type	311.309
2f. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*) dominant or codominant	CARO-CARU Layer Type	311.307
2g. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	CARO-THOC Layer Type	311.547
2. *Carex rossii* (incl. *Potentilla glandulosa*, *Astragalus canadensis*, *Iliamna*, and *Rudbeckia*) poorly represented	3	
3. *Epilobium angustifolium* well represented (Choose first condition that fits)	EPAN Layer Group	459
3a. *Epilobium* dominant	EPAN-EPAN Layer Type	459.459
3b. *Castilleja* spp. (incl. *Thermopsis*, *Lupinus*, and *Pteridium*) dominant or codominant	EPAN-CAMI Layer Type	459.438
3c. *Fragaria* spp. dominant or codominant	EPAN-FRVE Layer Type	459.465
3d. *Carex geyeri* (incl. *Aster conspicuus*) dominant or codominant	EPAN-CAGE Layer Type	459.309
3e. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*) dominant or codominant	EPAN-CARU Layer Type	459.307
3f. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	EPAN-THOC Layer Type	459.547
3. *Epilobium angustifolium* poorly represented	4	
4. *Castilleja* spp. (incl. *Thermopsis*, *Lupinus*, and *Pteridium*) well represented (Choose first condition that fits)	CAMI Layer Group	438
4a. The above species dominant	CAMI-CAMI Layer Type	438.438
4b. *Fragaria* spp. dominant or codominant	CAMI-FRVE Layer Type	438.465
4c. *Carex geyeri* (incl. *Aster conspicuus*) dominant or codominant	CAMI-CAGE Layer Type	438.309
4d. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*) dominant or codominant	CAMI-CARU Layer Type	438.307
4e. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	CAMI-THOC Layer Type	438.547
4. *Castilleja* spp. (incl. *Thermopsis*, *Lupinus*, and *Pteridium*) poorly represented	5	

(con.)

Table 18 (Con.)

		ADP codes
5. *Fragaria* spp. well represented (Choose first condition that fits)	FRVE Layer Group	465
5a. *Fragaria* spp. dominant	FRVE-FRVE Layer Type	465.465
5b. *Carex geyeri* (incl. *Aster conspicuus*) dominant or codominant	FRVE-CAGE Layer Type	465.309
5c. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*) dominant or codominant	FRVE-CARU Layer Type	465.307
5d. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	FRVE-THOC Layer Type	465.547
5. *Fragaria* spp. poorly represented	6	
6. *Carex geyeri* (incl. *Aster conspicuus*) well represented (Choose first condition that fits)	CAGE Layer Group	309
6a. The above species dominant	CAGE-CAGE Layer Type	309.309
6b. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*) dominant or codominant	CAGE-CARU Layer Type	309.307
6c. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	CAGE-THOC Layer Type	309.547
6. *Carex geyeri* (incl. *Aster conspicuus*) poorly represented	7	
7. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis racemosa*) well represented (Choose first condition that fits)	CARU Layer Group	307
7a. The above species dominant	CARU-CARU Layer Type	307.307
7b. *Thalictrum occidentale* (incl. *Actaea*) dominant or codominant	CARU-THOC Layer Type	307.547
7. *Calamagrostis rubescens* (incl. *Arnica* and *Pedicularis*) poorly represented	8	
8. *Thalictrum occidentale* (incl. *Actaea*) well represented	THOC Layer Group	547
8a. The above species dominant	THOC-THOC Layer Type	547.547
8. *Thalictrum occidentale* (incl. *Actaea*) poorly represented	Depauperate or unclassified layer type.	

[1]"Well represented" means ≥5 percent canopy coverage; "dominant" refers to greatest canopy coverage; "codominant" refers to nearly equal canopy coverage.

ANNUALS LAYER GROUP (ANN. L.G.)

Annuals, mainly species of *Epilobium* and *Gayophytum* and occasionally *Polygonum*, *Collomia*, and *Cryptantha*, can develop high coverages on newly exposed soil in full sunlight. These taxa have little competitive ability, and their annual nature makes them vulnerable to replacement by any perennial. Likewise, biennials such as *Verbascum* and *Cirsium vulgare* and the short-lived perennials *Phacelia* and *Gnaphalium* must reestablish frequently in order to maintain high coverages. Without recurring disturbance these taxa are also easily replaced as succession advances. Relative amounts of these early seral colonizers vary considerably following disturbance and appear to be mainly a function of available seed. The Annuals layer group represents the earliest seral conditions of the herb layer and is usually replaced within the first 5 years following disturbance; however, it can be maintained by intense livestock use.

CAREX ROSSII LAYER GROUP (CARO L.G.)

Carex rossii is a nonrhizomatous sedge that stores its seed in the soil or duff (Kramer 1984). It sprouts readily following scarification but responds poorly to burning. On thoroughly scarified sites, *C. rossii* can dominate the herb layer and remain well represented until replaced by taller species. In spring, it provides some forage for large herbivores.

The perennial forb *Potentilla glandulosa* often associates with *C. rossii* but in ABGR/VAGL is less common than the *Carex*. It is nonrhizomatous and intolerant of shade. In sunlight, it flowers readily and produces large numbers of seed, which are stored in the soil (Kramer 1984) and germinate following scarification. The scarification can result from either mechanical treatment of the site or heavy livestock use. *Potentilla* seems to be less palatable to livestock than most associated herbs and can increase under grazing to the point of being the only species that is well represented on the site. This response is most evident on granitic soils; on nongranitic soils reaction to grazing is less pronounced but still evident from both sheep and cattle use.

Rudbeckia occidentalis is a nonrhizomatous perennial, with successional responses similar to those of *Potentilla*. One obvious difference, however, is that *Rudbeckia* tends to be a more successful invader on basalt parent materials whereas *Potentilla* is more successful on granitics. Because both types of soils are common in ABGR/VAGL, *Rudbeckia* is lumped as an alternate indicator of the CARO l.g.

Astragalus canadensis is a shade-intolerant, rhizomatous forb with seed that can be stored in the soil. The seed germinates readily in clearcuts following burning or scarification. *Astragulus* appeared only occasionally in ABGR/VAGL but when found was usually well represented in clearcut areas.

The above species respond mainly to scarification and, when well represented, indicate early seral stages of herb layer succession. As a result, this layer group may persist for many years if influenced by livestock but declines rapidly where shade develops. Most sample stands in this

layer group were disturbed less than 15 years ago (appendix C). Those disturbed more than 15 years ago have received repeated light to moderate livestock use. Six of the seven possible layer types in the CARO layer group (fig. 20) were encountered during field sampling. The most common of these, CARO-CARO, resulted from intensive machine scarification often followed by cattle grazing. Contour stripping and pile-and-burn operations were by far the most common site treatments throughout the CARO l.g.; grazing, mainly by cattle, was also common.

EPILOBIUM ANGUSTIFOLIUM LAYER GROUP (EPAN L.G.)

Epilobium angustifolium is a rhizomatous perennial that can establish readily from windblown seed. In open areas created by stand-destroying wildfire, it characteristically colonizes bare soil and forms extensive colonies that bloom profusely (Stickney 1985). *Epilobium*, however, does not always need burned areas for establishment. In clearcuts, it often appears on dozer-piled debris, burned or unburned, where soil and debris have been mixed. The required substrate for *Epilobium* is deep, loose soil, usually exposed by either fire or logging.

The EPAN l.g. represents early seral stages of herb layer succession (fig. 19). Of the six possible layer types, four were encountered (fig. 20). All sample plots resulted from clearcutting and at least some scarification 6 to 21 years ago. None of these sites was being grazed by livestock.

CASTILLEJA MINIATA LAYER GROUP (CAMI L.G.)

Castilleja miniata is a woody-based forb with some tolerance for light shade and grazing. In ABGR/VAGL, it occasionally develops relatively high coverages in lightly grazed stands of patchy timber or scattered tall shrubs. *Castilleja applegatei* may also be present on these sites and is considered a successional equivalent of *C. miniata*.

Thermopsis montana is a rhizomatous forb with seeds that can be stored in forest soil (Kramer 1984). Its tolerance for shade and grazing appears similar to that of *C. miniata*, and it occurs in similar site conditions. For these reasons, it was included in the CAMI l.g.

Species of *Lupinus*, mainly *L. laxiflorus* and *L. sericeus*, are occasionally well represented in ABGR/VAGL. These are nonrhizomatous deep-rooted forbs that can persist under light shade but attain their best development in full sun. Their relatively heavy seed is not apt to disperse widely and is likely stored in the soil. Responses to specific disturbances are not clear, but burning and grazing probably increase their numbers.

Pteridium is a rhizomatous fern capable of developing extensive colonies, especially with repeated burning. It can dominate forest openings for many decades, even without burning, and often maintains relatively pure stands. This latter trait has implicated *Pteridium* with allelopathic capability, a feature substantiated by Stewart (1975), Horsley (1977), and del Moral and Cates (1971). Apparently the senescent fronds produce the greatest inhibitory effects on certain herbaceous and woody vegetation but have not yet been shown to substantially inhibit conifers. Although it often grows vigorously in full sun, *Pteridium* can also increase under light shade but declines under a mature coniferous canopy. Because *Pteridium* is uncommon in ABGR/VAGL, it is not likely that it represents a complete layer group. For this reason it was subjectively lumped with the CAMI l.g. as the most similar successional stage.

The CAMI l.g. is a midseral stage that often replaces the CARO l.g. as grazing pressure declines. It generally appears in openings between tall shrubs or in patches of timber that deter livestock use. Further succession often leads to the FRVE l.g. Although the CAMI l.g. may occur throughout most of the ABGR/VAGL h.t., it is more common toward the drier extremes. Four of the five possible layer types in the CAMI l.g. were found (fig. 20). Only the CAMI-THOC layer type was not found but may occur following clearcutting and light scarification of a *Thalictrum*-dominated herb layer.

FRAGARIA VESCA LAYER GROUP (FRVE L.G.)

Fragaria vesca and *F. virginiana* can develop substantial coverages through their stoloniferous growth habit. This happens most frequently beneath a light canopy of trees or tall shrubs where partial shade has reduced competition from earlier successional herbs. Trampling from grazing animals can reduce the coverage of *Fragaria*, especially *F. vesca*. On cutover sites that are being heavily grazed, *Fragaria* often achieves notable development beneath the protection of large shrubs while the shrub interspaces contain mostly *Potentilla* and other species more tolerant of grazing. *Fragaria virginiana*, however, can endure light to moderate grazing pressure. In ABGR/VAGL, it tends to occur on the more gentle terrain generally associated with frost pockets and *Pinus contorta* sites. In contrast, *F. vesca* tends to be more abundant on steeper terrain that is better suited for *Pinus ponderosa*. Because both *Fragaria* species can also be well represented on the same site, they should not be used as absolute indicators of tree species suitability. Apparently *Fragaria vesca* can store small amounts of viable seed in the soil (Kramer 1984).

The FRVE layer group represents a midseral stage of forb layer succession and consists of four layer types in ABGR/VAGL. Two of these have been sampled (fig. 20). Most of the FRVE layer types sampled are the successional result of clearcut areas that were scarified 12 to 14 years ago. One sample resulted from a broadcast burn operation 18 years ago. Little or no grazing was evident on most of these sites.

CAREX GEYERI LAYER GROUP (CAGE L.G.)

Carex geyeri is a moderately shade-tolerant sedge found in many habitat types. It tends to grow in a bunch form, especially on dry granitic substrates, but also develops a loose rhizomatous form on more moist sites. Its extensive root system is an effective soil stabilizer, and the plant can resprout following light scarification. It has some ability to store seed in the soil (Kramer 1984). The stored seed apparently germinates following clearcutting and scarification. In spring, *C. geyeri* is one of the first plants

to produce new growth, which has considerable forage value for elk and bear (appendix C). This *Carex* generally persists in older stands but with increasing shade gives way to its common associates, *Calamagrostis rubescens*, *Arnica*, or *Thalictrum*. For this reason *C. geyeri* represents late seral stages of ABGR/VAGL herb layer succession (fig. 19).

Aster conspicuus is a moderately shade-tolerant forb that can maintain extensive colonies beneath pine and Douglas-fir. It can increase vegetatively by rhizomes when the tree canopy is reduced, and it apparently also increases following creeping ground fire. Its windblown seed provides long-distance dispersal and probably germinates on bare soil. In this manner, small amounts of *Aster* can establish following stand-destroying wildfire or clearcutting with scarification. The *Aster* can then increase vegetatively to form extensive colonies, which persist on well-timbered sites. For this reason, *Aster conspicuus* is considered successionally similar to *Carex geyeri* as an indicator of late seral stages (fig. 19).

The CAGE l.g. consists of three layer types, two of which were sampled (fig. 20). Four of the stands experienced partial loss of the tree canopy from wildfire about 50 to 70 years ago. The remaining stand was clearcut and lightly scarified 11 years ago. None of these sites were being grazed by livestock.

CALAMAGROSTIS RUBESCENS LAYER GROUP (CARU L.G.)

Calamagrostis rubescens is a rhizomatous grass that can maintain high coverages under moderate shade as well as in openings. With increased sunlight, *Calamagrostis* can acquire new vigor and easily dominate the herb layer. Its spring-summer forage value is considered high for bear and elk (appendix C).

Arnica cordifolia is a shade-tolerant rhizomatous forb that can develop substantial coverages in clearcuts or open stands of timber. But, on most ABGR/VAGL sites, *Arnica* displays low coverages beneath a shrub or tree canopy and persists in moderate shade more successfully than most other forbs. It shows little ability to increase from seed following any type of disturbance and, like most wind-dispersed species, does not store its seed in the soil (Kramer 1984). *Arnica* increases most effectively from residual plants following partial cutting without scarification and has moderate forage value for deer and elk (appendix C).

Pedicularis racemosa is not a common forb in ABGR/VAGL but occasionally is well represented beneath stands partially destroyed by wildfire. Although nonrhizomatous, *P. racemosa* can persist beneath a moderately dense tree canopy. It apparently does not store its seed in the soil (Kramer 1984), and its seedbed requirements are unknown. It has moderate forage value for deer and elk (appendix C).

The CARU l.g. consists of two layer types, both of which were sampled (fig. 20). The CARU-CARU layer type is more common than any other herb layer type in ABGR/VAGL. CARU-THOC is relatively scarce. In most cases, these two layer types resulted from successional advance. It is not likely that they can be generated directly from site treatment even though several sites had been clearcut. In these cases, site treatment did not effectively alter the herb layer composition and allowed a preexisting CARU layer type to remain intact. All but two of the sampled sites were receiving little or no livestock use; light use by deer was evident in some stands.

THALICTRUM OCCIDENTALE LAYER GROUP (THOC L.G.)

Thalictrum occidentale is a shade-tolerant rhizomatous forb that can produce high coverages in old-growth stands. No other species in the herb layer appears capable of replacing *Thalictrum* without the aid of disturbance. The *Thalictrum* coverage can be reduced by moderate scarification, burning, and in some cases, just removal of the tree canopy. *Thalictrum* does not appear capable of storing its seed in the soil (Kramer 1984).

Actaea rubra is a shade-tolerant forb that can increase vegetatively and form small clumps. In ABGR/VAGL, it is restricted to the most moist portions of the habitat type and indicates sites well suited for *Picea* and *Alnus*. Occasionally, *Actaea* becomes well represented where all other forbs are sparse and so is treated as an alternate climax indicator (fig. 19).

In ABGR/VAGL, the THOC-THOC layer type occurs throughout most of the habitat type but may be absent on the dry extremes. In these cases, the CARU-CARU layer type would be the successional endpoint. Being climax, THOC-THOC can only be attained through successional advance of younger layer types. It may also remain intact following creeping ground fire that does not destroy the *Thalictrum* rhizomes. Most of the sampled stands contained little or no sign of livestock use; occasional deer use was evident.

MANAGEMENT IMPLICATIONS

Management implications of the herbaceous layer focus on relative forage values to big game and livestock. A relative index to forage preferences by herb layer type (table 19) was developed by the same method used for the shrub layer (table 8). The palatability ratings given for each species in appendix C were multiplied by the percentage constancy and average canopy coverage shown for that species in a given layer type. This step was repeated for all species in that layer type, and the results were summed to give a relative forage index, which was then reduced to index classes (table 19). Some of the advantages and shortcomings of using this approach were previously noted (see shrub layer management implications). Range and wildlife managers who have better palatability ratings for a local area can easily recalculate the forage preference indexes from appendix C. Users of table 19 should consider the often small sample size of some layer types and possible revision of index values with increased sampling. As more data become available, these forage preference indexes can provide general guidelines to grazing potential for specific management objectives. When both herb and shrub layer types are known for a given site, the index values assigned in table 19 can be added to those in table 8 to give a total forage index for that site.

Table 19—Relative index classes to big-game and livestock forage preferences by herb layer type in ABGR/VAGL h.t.[1]

Layer group layer type	No. of stands	Deer		Elk		Cattle	Sheep	Black bear		
		SU[2]	W	SU	W	SU	SU	SP	SU	F
Carex rossii										
CARO-CARO	12	[3]1	1	1	1	1	1	1	1	0
CARO-CAMI	5	2	1	2	1	1	2	1	1	0
CARO-FRVE	3	2	1	1	1	1	2	1	1	0
CARO-CAGE	1	1	1	2	1	2	2	2	1	1
CARO-CARU	1	1	1	2	1	2	2	1	1	0
CARO-THOC	1	1	1	2	1	1	2	1	1	0
Epilobium angustifolium										
EPAN-EPAN	1	1	0	1	0	0	1	0	0	0
EPAN-CAGE	2	2	1	2	1	2	2	1	1	0
EPAN-CARU	2	2	2	5	2	4	3	3	2	1
EPAN-THOC	1	1	0	2	0	1	1	0	0	0
Castilleja miniata										
CAMI-CAMI	1	1	0	1	0	1	1	0	0	0
CAMI-FRVE	2	2	1	2	1	2	2	2	1	1
CAMI-CAGE	1	1	1	2	1	1	1	1	1	0
CAMI-CARU	2	2	2	4	3	4	3	3	2	1
Fragaria vesca										
FRVE-FRVE	1	2	2	1	2	1	2	1	2	1
FRVE-CARU	3	2	2	2	2	2	2	2	2	1
Carex geyeri										
CAGE-CAGE	2	1	1	1	1	1	1	1	0	0
CAGE-CARU	3	1	1	2	2	2	1	2	1	1
Calamagrostis rubescens										
CARU-CARU	14	1	1	2	1	2	2	2	1	1
CARU-THOC	1	2	1	2	1	2	2	1	1	0
Thalictrum occidentalis										
THOC-THOC	5	1	1	2	1	1	1	0	0	0

[1]Based on palatability ratings by Kufeld (1973), Kufeld and others (1973), USDA-FS (n.d.), and Beecham (1981).
[2]SP = spring (March, April, May); SU = summer (June, July, August); F = fall (September, October, November); W = winter (December, January, February).
[3]Code to index classes: 0 = 0-50; 1 = 51-150; 2 = 151-250; 3 = 251-350; 4 = 351-450; 5 = 451-550; 6 = 551-650; 7 = 651-750.

Deer—In contrast to the shrub layer, herb layer forage values for deer are low to nil in all seral conditions sampled to date (table 19). These values reflect the combined effects of relatively low herb layer canopy coverages on these cool sites and the relatively low palatability of most herb layer species in ABGR/VAGL (appendix C). But certain shrub layer types on these same sites ranked moderate to high for summer deer herds (table 8).

Elk—Herb layer forage values for elk are mostly low, but a few layer types have moderate value. The highest values to date are in the EPAN-CARU and CAMI-CARU herb layer types (table 19). These values hinge mainly on the high coverages and high palatability of *Calamagrostis rubescens* (appendix C). Following tree removal, the *Calamagrostis* can easily attain high coverages in early to midseral stages but may decline somewhat under the denser tree canopies associated with late seral to near climax conditions.

Cattle—Herb layer forage values for cattle are mostly low throughout ABGR/VAGL succession (table 19). Only the EPAN-CARU and CAMI-CARU layer types, which ranked highest for elk, have moderate value for cattle. It is noteworthy that corresponding values for summer elk equal or exceed those for cattle in all herb layer types. The same is true of the shrub layer types where forage values for cattle are generally low while those for elk may be moderate to high (table 8).

Sheep—Herb layer forage values for sheep in ABGR/VAGL are similar to those for cattle, with the highest values again being in the EPAN-CARU and CAMI-CARU layer types. The sheep, however, have somewhat higher forage values than cattle in the shrub layer suggesting that ABGR/VAGL sites are better suited for sheep than for cattle.

Black Bear—The pattern of forage values for bear in ABGR/VAGL herb layer types is generally low to occasionally moderate. The highest forage values for black bear result from high coverages of *Calamagrostis* and occur in the CAMI-CARU and EPAN-CARU herb layer types during the spring (table 19). These two herb layer types are most easily achieved by removing the tree canopy of stands containing *Calamagrostis* and lightly scarifying the site. On some sites, prescribed surface fires designed to stimulate the *Calamagrostis* and eliminate small *Abies* and *Pseudotsuga* as well as the logging slash, may also contribute to these two herb layer types.

Pocket Gophers—The relationships between pocket gopher occurrence and silvicultural activities were discussed in the tree layer section. In general, scarification without burning resulted in the most gopher activity (table 3). The scarification generally produces early seral herb layer types which apparently stimulate gopher populations. The scarification producing these herb layers can result from either machinery or heavy livestock use and may account for the observed correlation between heavy grazing and high gopher activity (Buechner 1942). The relationship between gopher activity and early seral herb layers created by scarification without burning was also found in other habitat types (Steele and Geier-Hayes 1985, 1986). In contrast, other disturbances, such as broadcast burning, generally result in either a depauperate herb layer, often due to rapid shrub development, or a more successionally advanced herb layer type. These conditions often result in less gopher activity.

In summarizing studies of pocket gophers, Teipner and others (1983) suggest that plant species composition and abundance are the main regulators of gopher density. More specifically, Andersen and MacMahon (1981) correlated gopher population decline in a spruce-fir forest with decreasing palatable vegetation due to advancing successional stages. Succession in ABGR/VAGL, especially the herbaceous layer, also appears related to gopher activity. Here, occurrence and number of gopher mounds were tallied in either a 538-ft^2 (50-m^2) or 4,037-ft^2 (375-m^2) circular plot and summarized according to herb layer type (fig. 21). Because not all gopher activity results in new mounds, the number of mounds per acre may at times be a poor reflection of gopher density but should indicate relative activity between sites in the upper soil profile where feeding occurs.

Although pocket gophers are seldom a serious problem in ABGR/VAGL, figure 21 shows that gopher activity is highest in the CARO l.g. Herb layer types in this group are generated mainly from scarification without burning. Except for two sample plots, gopher activity in the more advanced herb layer types was virtually nil (fig. 21). This trend is similar to that found by Andersen and MacMahon (1981) and further suggests that certain early seral species

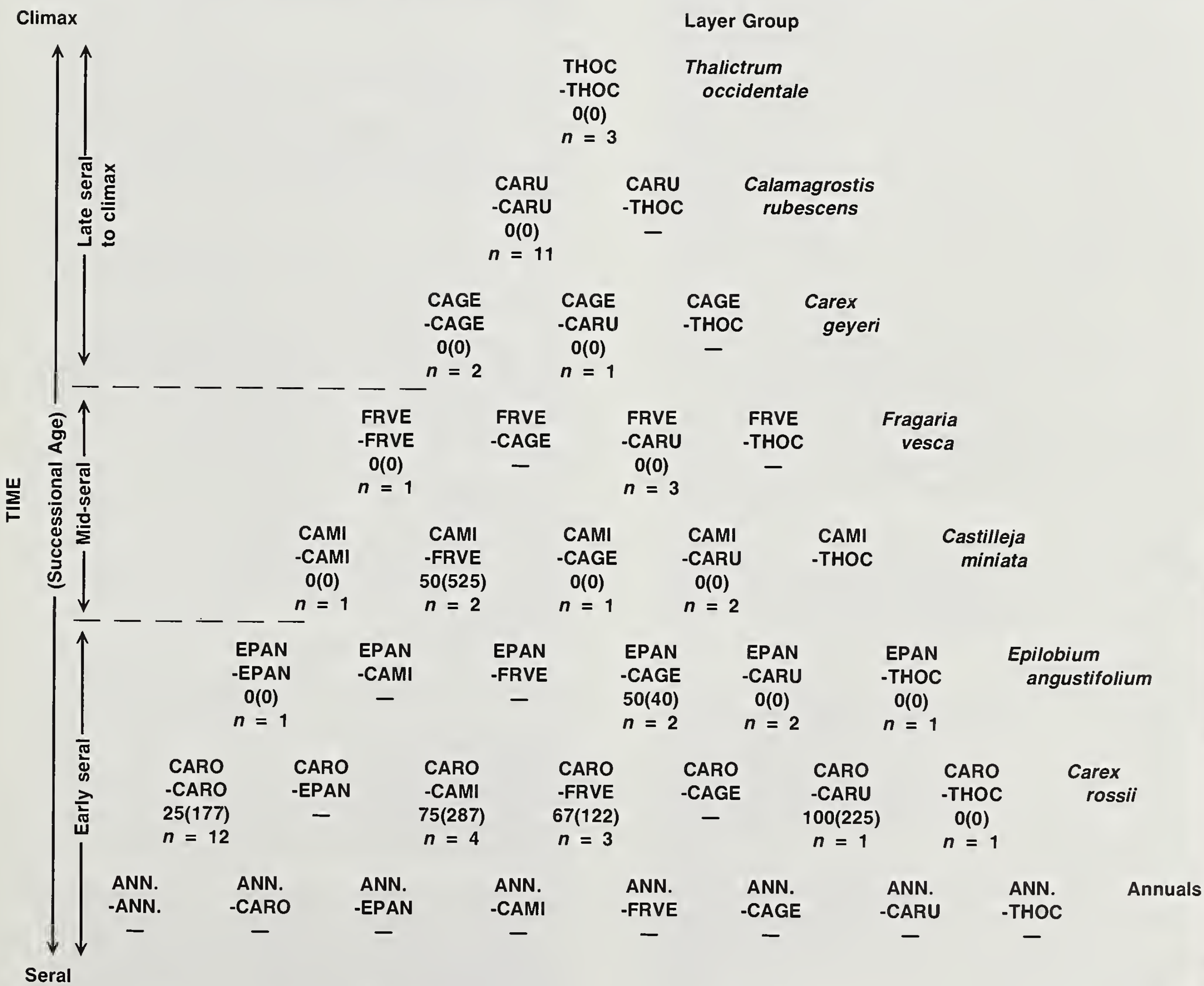

Figure 21—Constancy and average number per acre of pocket gopher mounds in various herb layer types (n = number of samples).

may provide the greatest benefit to gophers. In laboratory feeding tests, gophers gained or maintained body weight on exclusive diets of both *Taraxacum* and *Erigeron*, and generally maintained their weight on *Bromus carinatus* and *Bromus inermis* (Tietjen and others 1967). In ABGR/VAGL, all of these taxa would be early seral species similar to *Carex rossii*. In contrast, gophers died on exclusive diets of *Geranium* (Tietjen and others 1967) and *Epilobium angustifolium* (Andersen and MacMahon 1985), both of which have greater successional amplitude than *Carex rossii*. Although inconclusive at this point and not applicable to all species, additional feeding tests using a wider variety of plant species may substantiate this trend.

SUMMARY OF HERB LAYER SECTION

The herb layer classification consists of eight layer groups and 36 layer types. It contains more variability than the tree or shrub layer classification and may eventually require more refinement.

The annuals layer group can result from either burning or scarification. It is usually of short duration but can be maintained by intense livestock use. The CARO l.g. usually results from thorough scarification without burning and can be maintained by heavy livestock use. The EPAN l.g. usually results from burning or otherwise exposing deep loose soil. In ABGR/VAGL these two layer groups reflect early seral stages.

The CAMI l.g. usually results from successional advance of the CARO l.g. and occurs mainly on the drier portions of ABGR/VAGL. The FRVE l.g. also results mainly from successional advance but occurs throughout ABGR/VAGL. Both of these herb layer groups are considered midseral stages in ABGR/VAGL.

The CAGE, CARU, and THOC l.g.'s usually result from successional advance but may also appear in cutover areas where the site received little or no disturbance. All of these are considered late seral to climax layer groups.

Forage value of the herb layer for big game and livestock is mostly low throughout ABGR/VAGL succession. Only the CAMI-CARU and EPAN-CARU l.t.'s had moderate value, in this case for summer elk herds and spring bear.

Pocket gophers are generally not a serious problem in ABGR/VAGL. Clearcutting followed by both scarification (without burning) and repeated grazing, however, is likely to result in high gopher activity.

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APPENDIX A: CONSTANCY[1] AND AVERAGE CANOPY COVERAGE (PERCENT, IN PARENTHESES) OF TREES BY LAYER TYPE IN ABGR/VAGL H.T., SHOWING SIZE CLASS DISTRIBUTION AND AVERAGE BASAL AREAS

TREE LAYER GROUP		*Pinus contorta*											
Tree layer type		PICO - PICO				PICO - PIPO				PICO - PSME			
Size class notation		s. PICO - s. PICO				p. PICO - o.g. PIPO				p. PICO - s. PSME			
Number of stands		*n* = 7				*n* = 1				*n* = 2			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	—	3(2.0)	3(0.5)	10(10.0)	—	10(0.1)	10(3.0)	5(15.0)	5(15.0)	10(6.0)	10(9.0)
002	*Abies lasiocarpa*	—	—	—	3(0.2)	—	10(0.1)	10(0.5)	10(4.0)	—	—	—	—
006	*Larix occidentalis*	—	—	—	3(0.5)	—	—	—	—	—	5(0.1)	—	—
007	*Picea engelmannii*	—	—	—	9(1.3)	—	—	—	—	—	—	—	—
010	*Pinus contorta*	—	—	—	10(28.0)	—	10(3.0)	10(15.0)	10(3.0)	—	10(2.0)	10(15.0)	10(2.0)
013	*Pinus ponderosa*	—	—	—	4(1.3)	10(15.0)	10(3.0)	—	—	10(10.0)	—	—	—
014	*Populus tremuloides*	—	—	—	1(0.5)	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	1(3.0)	1(3.0)	6(4.1)	—	—	10(3.0)	10(3.0)	—	10(9.0)	5(15.0)	10(18.0)
Average basal area (ft²/acre)		13				187				102			

TREE LAYER GROUP		*Pinus contorta*											
Tree layer type		PICO - PIEN				PICO - ABGR							
Size class notation		p. PICO - p. PIEN				p. PICO - p. ABGR				p. PICO - o.g. ABGR			
Number of stands		*n* = 1				*n* = 2				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	—	—	10(3.0)	10(9.0)	10(15.0)	10(15.0)	10(9.0)	10(38.0)	—	10(3.0)	10(3.0)
002	*Abies lasiocarpa*	—	—	10(0.1)	—	—	5(0.1)	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	—	—	—	—	—	—	—	—	—
007	*Picea engelmannii*	—	10(0.1)	10(45.0)	10(15.0)	5(15.0)	—	10(0.1)	10(0.5)	—	—	—	—
010	*Pinus contorta*	—	—	10(15.0)	—	5(15.0)	5(3.0)	10(15.0)	5(0.1)	—	10(3.0)	10(15.0)	10(0.1)
013	*Pinus ponderosa*	—	—	—	—	—	—	—	—	—	—	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	10(0.5)	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	—	—	—	—	—	—	5(0.5)	—	10(3.0)	10(0.1)	—
Average basal area (ft²/acre)		168				238				220			

[1]Code to constancy values: + = 0 - 5%, 1 = 5 - 15%, 2 = 15 - 25%, 3 = 25 - 35%, 4 = 35 - 45%, 5 = 45 - 55%, 6 = 55 - 65%, 7 = 65 - 75%, 8 = 75 - 85%, 9 = 85 - 95%, 10 = 95 - 100%

(con.)

APPENDIX A. (Con.)[1]

TREE LAYER GROUP		*Pinus contorta*				*Larix occidentalis*							
Tree layer type		PICO - ABGR				LAOC - LAOC				LAOC - PSME			
Size class notation		m. PICO - p. ABGR				s. LAOC - s. LAOC				m. LAOC - p. PSME			
Number of stands		*n* = 1				*n* = 1				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	10(3.0)	10(15.0)	10(10.0)	—	—	—	10(0.5)	—	—	10(15.0)	10(15.0)
002	*Abies lasiocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	—	—	—	—	10(10.0)	—	10(15.0)	10(3.0)	—
007	*Picea engelmannii*	—	—	10(3.0)	10(0.5)	—	—	—	10(3.0)	—	—	—	—
010	*Pinus contorta*	—	10(15.0)	10(3.0)	10(0.5)	—	—	—	—	—	—	—	—
013	*Pinus ponderosa*	—	—	—	—	—	—	—	10(3.0)	—	—	10(15.0)	10(0.5)
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	10(0.5)	—	—	—	—
016	*Pseudotsuga menziesii*	—	10(3.0)	10(3.0)	10(0.5)	—	—	—	10(1.0)	—	—	10(20.0)	10(15.0)
Average basal area (ft^2/acre)		143				3				115			

TREE LAYER GROUP		*Larix occidentalis*											
Tree layer type		LAOC - PSME								LAOC - PIEN			
Size class notation		o.g. LAOC - m. PSME				o.g. LAOC - o.g. PSME				m. LAOC - p. PIEN			
Number of stands		*n* = 1				*n* = 1				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	10(3.0)	—	10(15.0)	10(15.0)	10(3.0)	10(15.0)	10(3.0)	10(15.0)	10(15.0)	—	10(3.0)	10(3.0)
002	*Abies lasiocarpa*	—	—	—	—	—	—	—	10(3.0)	—	—	—	—
006	*Larix occidentalis*	10(15.0)	—	—	—	10(15.0)	—	—	—	10(3.0)	10(15.0)	—	—
007	*Picea engelmannii*	—	—	—	10(0.5)	—	—	10(0.1)	10(0.5)	—	—	10(20.0)	10(3.0)
010	*Pinus contorta*	—	—	10(3.0)	10(3.0)	—	10(0.1)	10(0.1)	—	—	—	—	—
013	*Pinus ponderosa*	—	—	—	—	—	—	—	—	—	—	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	10(15.0)	10(38.0)	10(0.1)	10(3.0)	10(38.0)	10(3.0)	10(3.0)	10(0.5)	—	—	10(15.0)	10(3.0)
Average basal area (ft^2/acre)		180				234				191			

[1]Code to constancy values: + = 0 - 5%; 1 = 5 - 15%; 2 = 15 - 25%; 3 = 25 - 35%; 4 = 35 - 45%; 5 = 45 - 55%; 6 = 55 - 65%; 7 = 65 - 75%; 8 = 75 - 85%; 9 = 85 - 95%; 10 = 95 - 100%

(con.)

APPENDIX A. (Con.)[1]

TREE LAYER GROUP		*Larix occidentalis*								*Pinus ponderosa*			
Tree layer type		LAOC - PIEN				LAOC - ABGR				PIPO - PIPO			
Size class notation		o.g. LAOC - p. PIEN				s. LAOC - s. ABGR				s. PIPO - s. PIPO			
Number of stands		*n* = 1				*n* = 1				*n* = 14			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	—	10(15.0)	10(15.0)	10(3.0)	—	—	10(38.0)	1(0.1)	—	1(3.0)	6(0.8)
002	*Abies lasiocarpa*	—	—	10(15.0)	10(3.0)	—	—	—	—	—	—	—	1(0.1)
006	*Larix occidentalis*	10(15.0)	—	—	—	10(3.0)	—	—	10(20.0)	—	—	—	1(3.0)
007	*Picea engelmannii*	—	10(15.0)	10(20.0)	10(3.0)	—	—	—	10(3.0)	—	—	—	3(1.0)
010	*Pinus contorta*	—	—	—	—	—	—	—	—	—	—	—	4(1.0)
013	*Pinus ponderosa*	—	—	—	—	—	—	—	10(0.5)	1(0.1)	—	2(3.0)	10(27.0)
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	1(1.0)
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	3(0.5)
016	*Pseudotsuga menziesii*	—	—	—	—	—	—	—	10(5.0)	1(4.0)	—	1(10.0)	6(2.0)
Average basal area (ft^2/acre)			141				136				20		

TREE LAYER GROUP		*Pinus ponderosa*											
Tree layer type		PIPO - PIPO											
Size class notation		s. PIPO - p. PIPO				o.g. PIPO - o.g. PIPO				s. PIPO - p. PSME			
Number of stands		*n* = 3				*n* = 1				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	—	—	10(1.0)	—	—	10(3.0)	10(10.0)	—	—	10(0.1)	10(0.1)
002	*Abies lasiocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	—	—	—	10(0.1)	—	—	—	—	—
007	*Picea engelmannii*	—	—	—	7(1.0)	—	—	10(0.3)	10(0.5)	—	—	—	—
010	*Pinus contorta*	—	—	7(4.0)	3(0.5)	—	—	—	—	—	—	—	10(0.5)
013	*Pinus ponderosa*	—	—	10(30.0)	10(13.0)	10(20.0)	—	—	10(0.5)	—	—	—	10(15.0)
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	—	3(3.0)	3(0.5)	—	—	10(3.0)	10(3.0)	—	—	10(15.0)	—
Average basal area (ft^2/acre)			56				91				—		

[1]Code to constancy values: + = 0 - 5%, 1 = 5 - 15%, 2 = 15 - 25%, 3 = 25 - 35%, 4 = 35 - 45%, 5 = 45 - 55%, 6 = 55 - 65%, 7 = 65 - 75%, 8 = 75 - 85%, 9 = 85 - 95%, 10 = 95 - 100%

(con.)

APPENDIX A. (Con.)[1]

TREE LAYER GROUP		Pinus ponderosa											
Tree layer type		PIPO - PSME								PIPO - ABGR			
Size class notation		o.g. PIPO - m. PSME				o.g. PIPO - o.g. PSME				o.g. PIPO - p. ABGR			
Number of stands		$n = 1$				$n = 1$				$n = 2$			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	10(20.0)	10(10.0)	10(15.0)	—	—	10(10.0)	—	—	—	10(34.0)	10(9.0)
002	*Abies lasiocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	10(3.0)	—	10(3.0)	—	—	—	—	5(3.0)	5(0.1)	5(0.1)
007	*Picea engelmannii*	—	—	—	—	—	—	—	—	—	—	—	—
010	*Pinus contorta*	—	—	—	—	—	—	—	—	—	—	—	—
013	*Pinus ponderosa*	10(15.0)	—	—	—	10(15.0)	—	—	—	10(15.0)	—	5(0.1)	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	10(15.0)	10(20.0)	10(3.0)	10(62.0)	—	10(10.0)	—	10(15.0)	5(10.0)	5(20.0)	5(3.0)
Average basal area (ft²/acre)		175				192				223			

TREE LAYER GROUP		Pseudotsuga menziesii											
Tree layer type		PSME - PSME				PSME - ABGR							
Size class notation		p . PSME - m. PSME				p. PSME - p. ABGR				p. PSME - o.g. ABGR			
Number of stands		$n = 1$				$n = 2$				$n = 1$			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	—	—	10(10.0)	—	10(12.0)	10(26.0)	5(15.0)	10(38.0)	—	10(3.0)	10(3.0)
002	*Abies lasiocarpa*	—	—	—	10(0.5)	—	—	—	—	—	10(15.0)	10(15.0)	10(0.1)
006	*Larix occidentalis*	—	10(3.0)	—	—	—	—	—	—	—	—	—	—
007	*Picea engelmannii*	—	10(15.0)	10(3.0)	—	—	—	5(3.0)	—	—	10(0.1)	10(3.0)	10(3.0)
010	*Pinus contorta*	—	—	—	—	—	—	—	5(0.5)	—	—	—	—
013	*Pinus ponderosa*	—	—	—	—	—	—	5(0.1)	5(0.5)	—	—	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	5(0.5)	—	—	—	—
016	*Pseudotsuga menziesii*	10(15.0)	10(20.0)	10(10.0)	—	—	—	10(15.0)	—	—	10(15.0)	10(15.0)	10(0.5)
Average basal area (ft²/acre)		242				71				162			

[1]Code to constancy values: + = 0 - 5%, 1 = 5 - 15%, 2 = 15 - 25%, 3 = 25 - 35%, 4 = 35 - 45%, 5 = 45 - 55%, 6 = 55 - 65%, 7 = 65 - 75%, 8 = 75 - 85%, 9 = 85 - 95%, 10 = 95 - 100%

(con.)

APPENDIX A. (Con.)[1]

TREE LAYER GROUP		Pseudotsuga menziesii											
Tree layer type		PSME - ABGR											
Size class notation		m. PSME - p. ABGR				o.g. PSME - s. ABGR				o.g. PSME - p. ABGR			
Number of stands		*n* = 1				*n* = 3				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	10(10.0)	10(20.0)	10(3.0)	—	7(15.0)	10(7.0)	10(24.0)	10(15.0)	10(15.0)	10(20.0)	10(10.0)
002	*Abies lasiocarpa*	—	—	—	—	—	3(3.0)	7(9.0)	7(19.0)	—	—	—	—
006	*Larix occidentalis*	—	10(0.1)	10(0.1)	—	3(0.1)	—	—	—	10(0.1)	—	—	—
007	*Picea engelmannii*	—	—	—	—	—	—	3(3.0)	3(0.1)	—	—	10(3.0)	10(0.5)
010	*Pinus contorta*	—	—	10(3.0)	—	—	—	3(0.5)	3(0.1)	—	10(3.0)	10(3.0)	—
013	*Pinus ponderosa*	—	—	—	—	3(3.0)	3(3.0)	—	—	—	—	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	10(15.0)	10(3.0)	—	10(30.0)	—	7(9.0)	3(0.5)	10(15.0)	—	—	—
Average basal area (ft²/acre)		84				140				252			

TREE LAYER GROUP		Pseudotsuga menziesii							
Tree layer type		PSME - ABGR							
Size class notation		o.g. PSME - m. ABGR				o.g. PSME - o.g. ABGR			
Number of stands		*n* = 1				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species								
001	*Abies grandis*	10(10.0)	10(30.0)	10(15.0)	10(0.5)	10(20.0)	10(15.0)	10(10.0)	10(15.0)
002	*Abies lasiocarpa*	—	—	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	—	—	—	10(0.1)	—
007	*Picea engelmannii*	—	—	10(0.5)	10(0.5)	—	10(3.0)	10(3.0)	10(0.5)
010	*Pinus contorta*	—	10(3.0)	10(3.0)	10(0.5)	—	—	—	—
013	*Pinus ponderosa*	—	—	—	—	—	—	—	10(0.5)
014	*Populus tremuloides*	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	10(15.0)	—	10(0.5)	10(0.1)	10(15.0)	—	—	—
Average basal area (ft²/acre)		223				128			

[1]Code to constancy values: + = 0 - 5%; 1 = 5 - 15%; 2 = 15 - 25%; 3 = 25 - 35%; 4 = 35 - 45%; 5 = 45 - 55%; 6 = 55 - 65%; 7 = 65 - 75%; 8 = 75 - 85%; 9 = 85 - 95%; 10 = 95 - 100%

(con.)

APPENDIX A. (Con.)[1]

TREE LAYER GROUP		Picea engelmannii											
Tree layer type		PIEN - PIEN				PIEN - ABGR							
Size class notation		o.g. PIEN - o.g. PIEN				p. PIEN - o.g. ABGR				m. PIEN - p. ABGR			
Number of stands		*n* = 1				*n* = 1				*n* = 2			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	10(15.0)	10(3.0)	10(3.0)	10(3.0)	10(45.0)	—	10(15.0)	10(3.0)	10(12.0)	10(12.0)	10(20.0)	10(15.0)
002	*Abies lasiocarpa*	—	10(0.1)	10(3.0)	10(3.0)	—	—	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	—	—	—	—	—	—	—	—	—
007	*Picea engelmannii*	10(38.0)	10(3.0)	10(0.5)	10(3.0)	10(38.0)	—	10(15.0)	10(0.5)	—	10(18.0)	10(3.0)	5(0.5)
010	*Pinus contorta*	—	—	—	—	—	—	—	—	—	—	—	—
013	*Pinus ponderosa*	—	—	—	—	—	—	—	—	—	—	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	—	—	—	—	—	—	—	—	—	—	—
Average basal area (ft^2/acre)		182				318				120			

TREE LAYER GROUP		Abies grandis											
Tree layer type		ABGR - ABGR											
Size class notation		s. ABGR - s. ABGR				s. ABGR - p. ABGR				s. ABGR - m. ABGR			
Number of stands		*n* = 1				*n* = 1				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	—	—	—	10(15.0)	10(15.0)	—	10(38.0)	10(20.0)	10(15.0)	10(20.0)	10(15.0)	10(15.0)
002	*Abies lasiocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	10(0.5)	—	—	10(3.0)	10(0.5)	—	—	—	—
007	*Picea engelmannii*	—	—	—	—	—	—	—	10(0.5)	—	—	—	—
010	*Pinus contorta*	—	—	—	—	—	—	—	—	—	—	10(3.0)	10(0.5)
013	*Pinus ponderosa*	—	—	—	10(0.5)	—	—	—	—	—	—	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	10(0.5)	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	—	—	10(0.5)	—	—	10(3.0)	—	—	—	10(0.5)	—
Average basal area (ft^2/acre)		—				194				172			

[1]Code to constancy values: + = 0 - 5%, 1 = 5 - 15%, 2 = 15 - 25%, 3 = 25 - 35%, 4 = 35 - 45%, 5 = 45 - 55%, 6 = 55 - 65%, 7 = 65 - 75%, 8 = 75 - 85%, 9 = 85 - 95%, 10 = 95 - 100%

(con.)

APPENDIX A. (Con.)[1]

TREE LAYER GROUP		Abies grandis											
Tree layer type		ABGR - ABGR											
Size class notation		s. ABGR - o.g. ABGR				p. ABGR - p. ABGR				p. ABGR - o.g. ABGR			
Number of stands		*n* = 2				*n* = 2				*n* = 1			
Size classes (inches)		>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4	>18	18 - 12	12 - 4	<4
ADP No.	Species												
001	*Abies grandis*	10(29.0)	10(9.0)	10(15.0)	10(18.0)	10(12.0)	10(18.0)	10(34.0)	10(2.0)	10(38.0)	—	10(15.0)	10(3.0)
002	*Abies lasiocarpa*	—	—	—	5(4.0)	—	—	5(0.1)	—	—	—	—	—
006	*Larix occidentalis*	—	—	—	—	—	—	—	—	—	—	—	—
007	*Picea engelmannii*	—	5(3.0)	—	5(3.0)	—	—	—	—	—	—	—	—
010	*Pinus contorta*	—	5(4.0)	—	5(0.5)	—	—	5(0.5)	—	—	—	10(0.5)	—
013	*Pinus ponderosa*	5(0.1)	—	—	—	5(0.1)	—	—	—	—	10(3.0)	—	—
014	*Populus tremuloides*	—	—	—	—	—	—	—	—	—	—	—	—
015	*Populus trichocarpa*	—	—	—	—	—	—	—	—	—	—	—	—
016	*Pseudotsuga menziesii*	—	5(0.1)	—	5(3.0)	5(3.0)	5(4.0)	—	—	—	10(3.0)	10(3.0)	—
Average basal area (ft^2/acre)		179				218				355			

[1]Code to constancy values: + = 0 - 5%, 1 = 5 - 15%, 2 = 15 - 25%, 3 = 25 - 35%, 4 = 35 - 45%, 5 = 45 - 55%, 6 = 55 - 65%, 7 = 65 - 75%, 8 = 75 - 85%, 9 = 85 - 95%, 10 = 95 - 100%

APPENDIX B: PALATABILITY RATINGS, CONSTANCY,[1] AND AVERAGE CANOPY COVERAGE (PERCENT, IN PARENTHESES) OF SHRUBS BY LAYER TYPE IN ABGR/VAGL H.T.

SHRUB LAYER GROUP											*Ceanothus velutinus*				
Shrub layer type											CEVE -CEVE	CEVE -RIVI	CEVE -SASC	CEVE -SPBE	CEVE -VAGL
Number of stands											*n* = 6	*n* = 1	*n* = 1	*n* = 2	*n* = 4
ADP	Palatability ratings[2]	Deer		Elk				Black bear							
No.	Species	Summer	Winter	Summer	Winter	Cattle	Sheep	Spring	Summer	Fall					
102	*Acer glabrum*	4	6	6	6	4	4	0	0	0	2(0.5)	10(15.0)	—	—	5(0.5)
104	*Alnus sinuata*	2	2	2	2	2	2	0	0	0	2(0.5)	—	—	—	3(0.5)
105	*Amelanchier alnifolia*	4	4	6	6	4	6	2	6	6	2(0.5)	—	—	5(3.0)	8(0.5)
203	*Berberis repens*	2	4	2	4	2	4	2	2	2	2(0.5)	—	—	—	—
107	*Ceanothus velutinus*	6	4	6	6	2	2	0	0	0	10(46.3)	10(15.0)	10(15.0)	10(26.3)	10(15.0)
114	*Lonicera involucrata*	4	4	4	4	2	2	2	4	4	2(0.5)	—	—	—	—
115	*Lonicera utahensis*	2	4	6	4	2	2	2	4	4	5(7.0)	10(3.0)	10(0.5)	5(3.0)	10(9.0)
118	*Pachistima myrsinites*	4	6	4	4	2	4	0	0	0	3(1.8)	10(3.0)	—	—	3(3.0)
122	*Physocarpus malvaceus*	4	2	4	2	2	4	0	0	0	3(7.8)	10(3.0)	—	—	3(0.5)
123	*Prunus emarginata*	4	4	6	4	2	2	2	4	6	5(0.5)	—	—	—	3(0.5)
128	*Ribes cereum*	4	6	2	6	2	2	2	6	4	2(0.5)	—	—	5(0.5)	—
130	*Ribes lacustre*	4	6	6	6	2	4	2	6	4	—	—	—	5(0.5)	8(1.3)
131	*Ribes viscosissimum*	4	6	6	6	2	4	2	6	4	5(5.3)	10(15.0)	10(3.0)	5(15.0)	8(0.5)
133	*Rosa gymnocarpa*	6	4	6	4	2	4	0	0	0	—	10(0.5)	—	—	8(1.3)
161	*Rosa nutkana*	6	4	6	4	2	4	0	0	0	5(0.5)	10(0.5)	10(0.5)	5(0.5)	3(0.5)
136	*Rubus parviflorus*	4	2	6	2	2	4	2	4	2	8(3.4)	—	10(0.5)	5(0.5)	5(20.3)
#02	*Salix* spp.	4	4	4	4	2	4	0	0	0	—	—	—	—	—
137	*Salix scouleriana*	6	6	6	6	2	4	0	0	0	7(14.6)	10(3.0)	10(37.5)	5(15.0)	10(14.0)
164	*Sambucus cerulea*	0	0	6	6	4	4	2	2	2	3(1.8)	—	—	—	3(0.5)
138	*Sambucus racemosa*	0	0	6	6	4	4	2	2	2	2(0.5)	—	—	—	—
139	*Shepherdia canadensis*	2	2	2	4	2	4	2	6	4	—	—	—	—	3(0.5)
140	*Sorbus scopulina*	6	4	6	4	2	4	2	2	6	3(1.8)	10(0.5)	—	—	3(0.5)
142	*Spiraea betulifolia*	4	2	4	4	2	4	0	0	0	10(8.2)	—	—	10(26.3)	10(12.0)
143	*Symphoricarpos albus*	4	2	6	6	2	4	2	2	2	2(0.5)	—	—	—	3(3.0)
163	*Symphoricarpos oreophilus*	4	2	2	4	2	4	2	2	2	2(0.5)	10(0.5)	—	—	—
146	*Vaccinium globulare*	6	4	6	2	2	4	2	6	4	8(7.3)	10(3.0)	10(3.0)	10(9.0)	10(38.1)
Years since disturbance - average:											14	11	11	18	16
- range:											6 - 18	11	11	11 - 25	7 - 24

[1]Code to constancy values: + = 0- 5% 2 = 15-25% 4 = 35-45% 6 = 55-65% 8 = 75-85% 10 = 95-100%
1 = 5-15% 3 = 25-35% 5 = 45-55% 7 = 65-75% 9 = 85-95%

[2]Forage ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.). and Beecham (1981).

(con.)

APPENDIX B. (Con.)[1]

SHRUB LAYER GROUP		Ribes viscosissimum					Salix scouleriana				
Shrub layer type		RIVI -RIVI	RIVI -SASC	RIVI -ALSI	RIVI -LOUT	RIVI -VAGL	SASC -SASC	SASC -ALSI	SASC -SPBE	SASC -LOUT	SASC -VAGL
Number of stands		*n* = 3	*n* = 1	*n* = 2	*n* = 4	*n* = 2	*n* = 3	*n* = 2	*n* = 4	*n* = 1	*n* = 8
ADP No.	Species										
102	*Acer glabrum*	—	—	—	3(0.5)	5(0.5)	—	5(0.5)	—	—	4(1.3)
104	*Alnus sinuata*	3(3.0)	—	10(50.0)	5(0.5)	—	3(0.5)	10(61.3)	—	—	6(14.7)
105	*Amelanchier alnifolia*	—	—	5(3.0)	5(1.8)	10(1.8)	7(3.0)	—	3(0.5)	10(0.5)	6(4.4)
203	*Berberis repens*	3(0.5)	—	—	—	—	3(0.5)	—	3(0.5)	—	—
107	*Ceanothus velutinus*	7(3.0)	10(3.0)	—	5(1.8)	5(3.0)	7(1.8)	5(3.0)	8(1.3)	10(3.0)	1(0.5)
114	*Lonicera involucrata*	—	—	—	—	—	3(0.5)	5(0.5)	—	—	1(3.0)
115	*Lonicera utahensis*	10(3.0)	10(3.0)	10(9.0)	10(26.3)	10(7.8)	10(5.3)	10(3.0)	8(12.8)	10(37.5)	10(11.7)
118	*Pachistima myrsinites*	3(3.0)	—	—	—	—	3(0.5)	—	—	—	1(0.5)
122	*Physocarpus malvaceus*	7(0.5)	—	5(0.5)	3(15.0)	5(0.5)	—	—	5(0.5)	10(0.5)	—
123	*Prunus emarginata*	3(0.5)	—	—	3(0.5)	—	3(0.5)	—	—	—	1(0.5)
128	*Ribes cereum*	3(0.5)	—	—	3(3.0)	5(0.5)	—	—	3(0.5)	10(0.5)	—
130	*Ribes lacustre*	3(15.0)	—	10(20.3)	5(15.0)	5(0.5)	—	5(3.0)	5(1.8)	—	4(0.5)
131	*Ribes viscosissimum*	10(38.3)	10(15.0)	10(19.0)	10(9.0)	10(15.0)	3(3.0)	10(3.0)	8(0.5)	10(0.5)	6(0.5)
133	*Rosa gymnocarpa*	10(0.5)	10(0.5)	10(0.5)	5(0.5)	10(0.5)	7(1.8)	—	5(0.5)	—	4(0.5)
161	*Rosa nutkana*	—	—	—	3(0.5)	5(3.0)	—	—	3(0.5)	10(0.5)	—
136	*Rubus parviflorus*	7(0.5)	—	10(0.5)	5(1.8)	5(0.5)	3(0.5)	5(3.0)	—	10(0.5)	4(0.5)
#02	*Salix* spp.	—	—	—	3(0.5)	—	—	—	—	—	1(0.5)
137	*Salix scouleriana*	10(2.2)	10(15.0)	10(9.0)	10(5.4)	10(7.8)	10(45.8)	10(15.0)	10(20.6)	10(15.0)	10(20.6)
164	*Sambucus cerulea*	3(0.5)	—	—	—	—	3(0.5)	—	—	10(0.5)	1(0.5)
138	*Sambucus racemosa*	3(0.5)	—	10(3.0)	8(1.3)	—	—	5(0.5)	3(0.5)	—	3(0.5)
139	*Shepherdia canadensis*	—	10(0.5)	—	3(0.5)	—	3(0.5)	10(7.8)	—	10(3.0)	8(2.2)
140	*Sorbus scopulina*	7(0.5)	—	—	5(0.5)	—	—	—	—	—	8(2.6)
142	*Spiraea betulifolia*	10(7.0)	—	10(7.8)	5(7.8)	10(1.8)	10(6.2)	5(15.0)	10(31.9)	10(3.0)	9(5.0)
143	*Symphoricarpos albus*	—	—	—	—	—	7(9.0)	—	—	—	—
163	*Symphoricarpos oreophilus*	3(0.5)	—	—	5(0.5)	—	—	—	3(0.5)	—	1(0.5)
146	*Vaccinium globulare*	10(6.2)	10(15.0)	10(7.8)	8(12.8)	10(37.5)	10(2.2)	10(19.0)	10(20.6)	10(15.0)	10(61.6)
Years since disturbance - average:		11	13	12	16	18	12	22	28	12	33
- range:		9 - 12	13	11 - 14	10 - 22	10 - 25	5 - 17	21 - 14	11 - 62	12	5 - 70

[1]Code to constancy values: + = 0- 5%, 1 = 5-15%, 2 = 15-25%, 3 = 25-35%, 4 = 35-45%, 5 = 45-55%, 6 = 55-65%, 7 = 65-75%, 8 = 75-85%, 9 = 85-95%, 10 = 95-100%

(con.)

APPENDIX B. (Con.)[1]

SHRUB LAYER GROUP		*Alnus sinuata*		*Spiraea betulifolia*			*Lonicera utahensis*		*Vaccinium globulare*
Shrub layer type		ALSI -SPBE	ALSI -VAGL	SPBE -SPBE	SPBE -LOUT	SPBE -VAGL	LOUT -LOUT	LOUT -VAGL	VAGL -VAGL
Number of stands		*n* = 1	*n* = 1	*n* = 4	*n* = 1	*n* = 5	*n* = 2	*n* = 14	*n* = 13
ADP No.	Species								
102	*Acer glabrum*	—	—	—	—	4(1.8)	5(3.0)	3(1.8)	2(2.2)
104	*Alnus sinuata*	10(15.0)	10(15.0)	—	—	—	—	1(3.0)	—
105	*Amelanchier alnifolia*	—	10(0.5)	3(0.5)	—	6(0.5)	10(1.8)	6(1.6)	5(1.9)
203	*Berberis repens*	—	—	3(0.5)	—	2(0.5)	—	1(0.5)	2(0.5)
107	*Ceanothus velutinus*	10(0.5)	—	8(1.3)	10(0.5)	2(3.0)	—	—	2(1.8)
114	*Lonicera involucrata*	—	—	3(0.5)	—	—	—	1(0.5)	—
115	*Lonicera utahensis*	10(3.0)	10(15.0)	5(0.5)	10(15.0)	8(14.6)	10(37.5)	10(15.0)	10(1.8)
118	*Pachistima myrsinites*	—	—	3(0.5)	—	—	—	4(4.9)	1(0.5)
122	*Physocarpus malvaceus*	10(0.5)	—	3(0.5)	—	—	5(15.0)	1(3.0)	2(1.3)
123	*Prunus emarginata*	—	—	—	—	—	—	1(3.0)	—
128	*Ribes cereum*	—	—	5(0.5)	—	—	—	1(0.5)	—
130	*Ribes lacustre*	10(0.5)	—	3(0.5)	—	2(0.5)	10(0.5)	1(0.5)	2(0.5)
131	*Ribes viscosissimum*	10(3.0)	—	10(1.1)	10(0.5)	2(0.5)	5(0.5)	5(1.2)	5(1.6)
133	*Rosa gymnocarpa*	10(0.5)	—	8(1.3)	10(3.0)	6(1.3)	10(1.8)	6(2.4)	6(1.4)
161	*Rosa nutkana*	—	—	3(0.5)	—	—	—	—	2(0.5)
136	*Rubus parviflorus*	10(15.0)	—	—	—	4(1.8)	10(1.8)	4(1.5)	5(1.3)
#02	*Salix* spp.	—	—	3(0.5)	10(0.5)	—	—	—	—
137	*Salix scouleriana*	10(3.0)	10(3.0)	8(2.2)	10(0.5)	4(1.8)	10(3.0)	4(2.2)	5(0.5)
164	*Sambucus cerulea*	—	—	—	—	—	—	—	—
138	*Sambucus racemosa*	—	—	3(0.5)	—	—	5(0.5)	1(0.5)	—
139	*Shepherdia canadensis*	—	10(0.5)	3(0.5)	—	6(6.2)	—	3(0.5)	1(0.5)
140	*Sorbus scopulina*	10(0.5)	10(3.0)	3(0.5)	—	6(1.3)	10(1.8)	6(0.8)	4(1.0)
142	*Spiraea betulifolia*	10(3.0)	10(3.0)	8(22.5)	10(15.0)	10(15.0)	10(0.5)	9(2.2)	7(1.6)
143	*Symphoricarpos albus*	—	—	5(7.8)	—	—	—	—	1(0.5)
163	*Symphoricarpos oreophilus*	—	—	2(0.5)	—	—	—	1(0.5)	2(1.8)
146	*Vaccinium globulare*	10(15.0)	10(85.0)	8(0.5)	10(3.0)	10(57.0)	10(15.0)	10(63.6)	10(49.0)
Years since disturbance - average:		10	70	4	9	49	52	75	85
- range:		10	70	4 - 5	9	14 - 80	15 - 90	45 - 120	14 - 170

[1]Code to constancy values: + = 0- 5% 2 = 15-25% 4 = 35-45% 6 = 55-65% 8 = 75-85% 10 = 95-100%
1 = 5-15% 3 = 25-35% 5 = 45-55% 7 = 65-75% 9 = 85-95%

APPENDIX C: PALATABILITY RATINGS, CONSTANCY,[1] AND AVERAGE PERCENTAGE CANOPY COVERAGE (PERCENT, IN PARENTHESES) OF HERBACEOUS SPECIES BY HERB LAYER TYPE IN ABGR/VAGL H.T.

HERB LAYER GROUP												*Carex rossii*				
Herb layer type												CARO -CARO	CARO -CAMI	CARO -FRVE	CARO -CAGE	CARO -CARU	CARO -THOC
Number of stands												*n* = 12	*n* = 5	*n* = 3	*n* = 1	*n* = 1	*n* = 1
	Palatability ratings[2]	Deer		Elk		Cattle	Sheep	Black bear								
ADP No.	Perennial graminoids	Summer	Winter	Summer	Winter	Summer	Summer	Spring	Summer	Fall						
336	*Agrostis scabra*	2	2	4	2	4	2	0	0	0	1(3.0)	—	—	—	—	—
303	*Bromus carinatus*	4	2	6	4	6	4	6	4	2	4(1.0)	8(4.8)	7(0.5)	—	10(0.5)	10(0.5)
304	*Bromus vulgaris*	4	2	4	4	6	4	6	4	2	—	—	3(0.5)	—	—	—
307	*Calamagrostis rubescens*	2	4	6	4	6	4	6	4	2	6(1.6)	6(1.3)	3(3.0)	10(0.5)	10(15.0)	10(0.5)
308	*Carex concinnoides*	4	4	4	4	2	6	6	4	2	3(1.3)	—	3(3.0)	—	10(0.5)	—
309	*Carex geyeri*	4	4	6	6	6	4	6	4	2	5(1.8)	4(1.8)	3(0.5)	10(15.0)	10(0.5)	10(3.0)
311	*Carex rossii*	2	2	4	2	2	4	6	4	2	10(12.8)	10(7.3)	7(7.8)	10(15.0)	10(3.0)	10(15.0)
318	*Festuca occidentalis*	4	4	4	6	6	6	0	0	0	1(0.5)	2(0.5)	7(0.5)	—	—	—
*04	*Phleum pratense*	4	4	2	6	6	6	6	4	2	1(0.5)	6(0.5)	3(0.5)	—	10(0.5)	—
	Ferns															
259	*Pteridium aquilinum*	4	0	2	0	2	4	0	0	0	—	2(15.0)	—	—	—	—
	Perennial forbs															
401	*Achillea millefolium*	2	2	2	2	2	4	0	0	0	7(0.5)	8(0.5)	10(0.5)	10(0.5)	—	—
402	*Actaea rubra*	4	0	2	0	2	2	0	0	0	—	—	—	—	—	—
405	*Anaphalis margaritacea*	2	2	2	2	2	2	0	0	0	2(0.5)	2(0.5)	7(1.8)	10(0.5)	10(0.5)	—
407	*Anemone piperi*	2	0	2	0	2	2	0	0	0	2(0.5)	2(0.5)	—	10(0.5)	—	—
414	*Antennaria microphylla*	4	2	2	2	2	4	0	0	0	1(0.5)	4(0.5)	7(0.5)	—	—	—
413	*Antennaria racemosa*	4	2	2	2	2	4	0	0	0	—	—	—	—	—	—
415	*Apocynum androsaemifolium*	2	0	2	0	2	2	0	0	0	—	—	—	—	—	—
421	*Arnica cordifolia*	4	0	4	0	2	4	0	0	0	3(1.1)	2(0.5)	3(0.5)	10(0.5)	—	10(0.5)
426	*Aster conspicuus*	2	2	4	2	4	4	0	0	0	2(0.5)	2(0.5)	7(0.5)	10(0.5)	—	10(0.5)
429	*Astragalus canadensis*	2	0	4	0	2	4	0	0	0	2(7.8)	—	—	10(0.5)	10(15.0)	—
438	*Castilleja miniata*	2	0	2	0	2	2	0	0	0	3(0.5)	2(15.0)	10(1.3)	—	10(0.5)	—
442	*Chimaphila umbellata*	0	0	0	0	0	0	0	0	0	—	—	—	—	—	—
*14	*Cirsium arvense*	2	2	2	2	2	2	0	0	0	4(0.5)	—	10(0.5)	—	—	—
596	*Cirsium scariosum*	2	2	2	2	2	2	0	0	0	—	2(0.5)	—	—	—	—
459	*Epilobium angustifolium*	4	2	6	2	2	4	0	0	0	8(0.8)	8(0.5)	3(3.0)	10(0.5)	10(0.5)	10(3.0)
889	*Epilobium watsonii*	2	0	2	0	2	2	0	0	0	1(0.5)	2(0.5)	3(0.5)	—	—	—
464	*Erythronium grandiflorum*	2	0	4	0	2	4	6	4	2	—	—	—	10(0.5)	—	—
467	*Fragaria* spp.	4	4	2	4	2	4	2	6	2	8(1.3)	10(4.4)	10(15.0)	10(0.5)	10(3.0)	10(0.5)

[1]Code to constancy values: + = 0- 5% 2 = 15-25% 4 = 35-45% 6 = 55-65% 8 = 75-85% 10 = 95-100%
1 = 5-15% 3 = 25-35% 5 = 45-55% 7 = 65-75% 9 = 85-95%

[2]Palatability ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.), and Beecham (1981).

(con.)

APPENDIX C. (Con.)[1]

HERB LAYER GROUP											Carex rossii					
Herb layer type											CARO -CARO	CARO -CAMI	CARO -FRVE	CARO -CAGE	CARO -CARU	CARO -THOC
Number of stands											*n* = 12	*n* = 5	*n* = 3	*n* = 1	*n* = 1	*n* = 1
	Palatability ratings[2]	Deer		Elk		Cattle	Sheep	Black bear								
ADP No.	Perennial forbs	Summer	Winter	Summer	Winter	Summer	Summer	Spring	Summer	Fall						
471	*Galium triflorum*	2	0	2	0	2	4	4	2	2	—	2(0.5)	3(0.5)	10(0.5)	—	—
473	*Geranium viscosissimum*	4	2	6	2	2	4	0	0	0	—	2(3.0)	7(0.5)	—	—	—
621	*Geum macrophyllum*	2	0	2	0	2	4	0	0	0	—	4(1.8)	3(0.5)	—	—	—
476	*Goodyera oblongifolia*	0	0	0	0	0	0	0	0	0	—	—	—	—	—	—
483	*Hieracium albertinum*	4	2	4	2	6	6	0	0	0	2(0.5)	4(0.5)	—	10(0.5)	—	10(0.5)
484	*Hieracium albiflorum*	4	2	4	2	6	6	0	0	0	3(0.5)	2(0.5)	—	10(0.5)	—	10(0.5)
833	*Iliamna rivularis*	4	0	6	0	4	6	0	0	0	1(15.0)	2(0.5)	—	—	—	—
636	*Lathyrus nevadensis*	4	2	4	2	6	6	0	0	0	—	—	—	—	—	—
499	*Lupinus* spp.	4	2	2	4	2	4	0	0	0	—	4(26.3)	—	10(0.5)	—	—
502	*Mitella stauropetala*	2	0	2	0	2	2	0	0	0	—	—	—	10(0.5)	—	—
505	*Osmorhiza chilensis*	2	0	2	0	2	4	6	4	2	2(0.5)	4(0.5)	3(0.5)	10(0.5)	—	10(0.5)
509	*Pedicularis racemosa*	4	0	4	0	2	2	0	0	0	—	4(0.5)	—	10(0.5)	—	—
658	*Penstemon attenuatus*	4	2	2	2	2	4	0	0	0	1(15.0)	4(1.8)	7(0.5)	—	—	10(0.5)
514	*Penstemon wilcoxii*	4	2	2	2	2	4	0	0	0	6(1.6)	2(0.5)	—	10(0.5)	—	—
519	*Polemonium pulcherrimum*	4	0	4	0	2	4	0	0	0	3(1.3)	10(1.0)	7(0.5)	—	—	10(0.5)
522	*Potentilla glandulosa*	4	2	4	2	2	4	0	0	0	8(4.8)	8(12.0)	7(7.8)	10(0.5)	10(0.5)	10(3.0)
528	*Pyrola picta*	0	0	0	0	0	0	0	0	0	—	—	—	—	—	—
529	*Pyrola secunda*	0	0	0	0	0	0	0	0	0	1(0.5)	—	—	—	—	—
675	*Rudbeckia occidentalis*	4	2	2	2	2	4	0	0	0	—	2(0.5)	3(15.0)	—	—	10(0.5)
*06	*Rumex acetosella*	2	0	2	0	2	2	0	0	0	2(0.5)	4(1.8)	—	—	—	—
542	*Smilacina racemosa*	6	2	4	2	2	4	6	4	2	3(0.5)	—	3(0.5)	10(0.5)	—	—
547	*Thalictrum occidentale*	4	2	6	2	2	4	0	0	0	5(0.9)	6(10.2)	10(2.2)	10(3.0)	—	10(15.0)
562	*Thermopsis montana*	2	2	2	2	2	2	6	2	2	—	2(15.0)	—	10(0.5)	—	—
*09	*Tragopogon dubius*	4	2	4	4	4	4	0	0	0	3(0.5)	—	—	—	10(0.5)	—
560	*Trillium ovatum*	0	0	0	0	0	0	4	4	2	3(0.5)	6(0.5)	—	10(0.5)	10(0.5)	—
551	*Valeriana sitchensis*	4	0	6	0	2	4	0	0	0	2(0.5)	4(0.5)	—	10(0.5)	10(0.5)	—
554	*Viola adunca*	2	0	2	0	4	6	0	0	0	1(0.5)	—	—	10(0.5)	—	—
557	*Viola orbiculata*	2	0	2	0	2	4	0	0	0	1(0.5)	—	—	—	—	—

[1]Code to constancy values: + = 0- 5%, 1 = 5-15%, 2 = 15-25%, 3 = 25-35%, 4 = 35-45%, 5 = 45-55%, 6 = 55-65%, 7 = 65-75%, 8 = 75-85%, 9 = 85-95%, 10 = 95-100%

[2]Palatability ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.), and Beecham (1981).

(con.)

APPENDIX C. (Con.)[1]

HERB LAYER GROUP											Carex rossii					
Herb layer type											CARO -CARO	CARO -CAMI	CARO -FRVE	CARO -CAGE	CARO -CARU	CARO -THOC
Number of stands											*n* = 12	*n* = 5	*n* = 3	*n* = 1	*n* = 1	*n* = 1
	Palatability ratings[2]	Deer		Elk		Cattle	Sheep	Black bear								
ADP No.	Annuals, biennials, and short-lived perennials	Summer	Winter	Summer	Winter	Summer	Summer	Spring	Summer	Fall						
#09	*Arabis* spp.	2	0	2	0	2	2	0	0	0	1(0.5)	2(0.5)	3(0.5)	—	—	—
*12	*Cirsium vulgare*	2	2	2	2	2	2	0	0	0	6(0.5)	4(0.5)	—	—	10(0.5)	10(0.5)
902	*Collinsia parviflora*	2	0	2	0	2	2	0	0	0	1(0.5)	—	—	10(0.5)	—	—
#56	*Collomia* spp.	2	0	2	0	2	2	0	0	0	1(0.5)	—	—	—	—	—
914	*Cryptantha affinis*	0	0	0	0	0	0	0	0	0	2(0.5)	—	—	—	—	—
904	*Epilobium paniculatum* (+ *E. minutum*)	2	0	2	0	2	2	0	0	0	3(3.0)	—	7(0.5)	—	—	—
930	*Gayophytum decipiens*	2	0	2	0	2	2	0	0	0	4(1.0)	2(3.0)	3(0.5)	—	—	—
886	*Gnaphalium microcephalum*	2	0	2	0	2	4	0	0	0	2(0.5)	—	3(0.5)	—	—	—
663	*Phacelia hastata*	4	2	4	2	2	4	0	0	0	3(0.5)	6(0.5)	3(0.5)	—	—	—
911	*Polygonum douglasii*	2	0	2	0	2	2	0	0	0	3(0.5)	2(0.5)	—	—	—	—
*16	*Verbascum thapsus*	2	2	2	2	2	2	0	0	0	2(0.5)	4(0.5)	—	—	10(0.5)	—
999	Bare soil										9(19.3)	10(10.2)	10(3.0)	10(15.0)	10(3.0)	10(3.0)
Years since disturbance - average											8	16	16	11	9	10
- range											3 - 18	11 - 25	11 - 22	11	9	10

[1]Code to constancy values: + = 0- 5%   2 = 15-25%   4 = 35-45%   6 = 55-65%   8 = 75-85%   10 = 95-100%
1 = 5-15%   3 = 25-35%   5 = 45-55%   7 = 65-75%   9 = 85-95%

[2]Palatability ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.), and Beecham (1981).

(con.)

APPENDIX C. (Con.)[1]

HERB LAYER GROUP		Castilleja miniata				Epilobium angustifolium				Fragaria vesca		Carex geyeri		Calamagrostis rubescens		Thalictrum occidentale
Herb layer type		CAMI -CAMI	CAMI -FRVE	CAMI -CAGE	CAMI -CARU	EPAN -EPAN	EPAN -CAGE	EPAN -CARU	EPAN -THOC	FRVE -FRVE	FRVE -CARU	CAGE -CAGE	CAGE -CARU	CARU -CARU	CARU -THOC	THOC -THOC
Number of stands		*n* = 1	*n* = 2	*n* = 1	*n* = 2	*n* = 1	*n* = 2	*n* = 2	*n* = 1	*n* = 1	*n* = 3	n = 2	*n* = 3	*n* = 14	*n* = 1	*n* = 5
ADP No.	**Perennial graminoids**															
336	*Agrostis scabra*	—	5(15.0)	—	—	—	—	—	—	10(3.0)	3(0.3)	—	—	—	—	—
303	*Bromus carinatus*	—	5(3.0)	10(0.5)	—	10(0.5)	10(0.5)	—	10(0.5)	10(0.5)	10(0.5)	—	—	2(0.5)	—	2(0.5)
304	*Bromus vulgaris*	—	—	—	—	—	—	—	—	—	—	5(0.5)	—	2(1.3)	10(0.5)	4(0.5)
307	*Calamagrostis rubescens*	10(0.5)	5(15.0)	—	10(50.0)	—	—	10(50.0)	—	—	10(18.5)	5(3.0)	10(15.0)	7(33.6)	10(15.0)	—
308	*Carex concinnoides*	—	5(15.0)	—	5(0.5)	—	5(37.5)	—	—	—	6(0.5)	—	3(0.5)	5(1.2)	—	—
309	*Carex geyeri*	10(0.5)	—	10(15.0)	—	—	—	5(0.5)	—	10(0.5)	10(1.3)	10(7.8)	10(15.0)	5(1.6)	10(0.5)	4(0.5)
311	*Carex rossii*	10(3.0)	10(3.0)	10(0.5)	—	10(0.5)	10(1.8)	10(0.5)	10(0.5)	10(0.5)	6(0.5)	5(0.5)	3(0.5)	5(0.5)	—	8(0.5)
318	*Festuca occidentalis*	10(0.5)	10(0.5)	—	—	—	—	—	—	—	6(0.5)	—	—	0(0.5)	—	2(0.5)
*04	*Phleum pratense*	—	5(0.5)	—	—	10(0.5)	5(0.5)	—	—	—	—	—	—	—	—	2(0.5)
	Ferns															
259	*Pteridium aquilinum*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Perennial forbs															
401	*Achillea millefolium*	—	10(0.5)	10(0.5)	—	10(0.5)	5(0.5)	10(0.5)	—	10(0.5)	6(0.5)	—	3(0.5)	1(0.5)	—	—
402	*Actaea rubra*	—	—	—	—	—	—	—	10(15.0)	—	—	—	—	—	—	6(5.3)
405	*Anaphalis margaritacea*	—	—	—	—	10(0.5)	10(1.8)	—	—	—	—	—	—	—	—	—
407	*Anemone piperi*	—	5(0.5)	—	—	—	—	—	—	—	—	—	—	2(0.5)	10(0.5)	4(0.5)
414	*Antennaria microphylla*	—	—	—	—	—	5(0.5)	—	10(0.5)	10(0.5)	3(0.5)	—	—	1(0.5)	—	—
413	*Antennaria racemosa*	—	—	—	—	—	—	—	—	—	3(0.5)	—	—	0(0.5)	10(0.5)	2(0.5)
415	*Apocynum androsaemifolium*	—	—	—	—	—	—	—	—	—	3(0.5)	—	3(0.5)	0(0.5)	—	—
421	*Arnica cordifolia*	10(0.5)	10(0.5)	10(0.5)	5(15.0)	—	—	10(7.8)	10(0.5)	—	10(6.2)	—	3(0.5)	7(13.3)	10(3.0)	4(1.8)
426	*Aster conspicuus*	—	—	—	—	10(0.5)	5(15.0)	5(0.5)	—	—	6(0.5)	10(7.8)	3(3.0)	2(0.5)	10(0.5)	2(0.5)
429	*Astragalus canadensis*	—	5(0.5)	—	—	—	—	—	—	—	—	—	—	—	—	—
438	*Castilleja miniata*	10(37.5)	10(7.8)	10(15.0)	—	—	5(0.5)	5(0.5)	—	—	3(0.5)	—	—	0(0.5)	—	—
442	*Chimaphila umbellata*	—	—	—	10(1.8)	—	—	—	—	—	—	10(1.8)	3(0.5)	7(1.3)	10(0.5)	6(3.0)
*14	*Cirsium arvense*	—	5(0.5)	—	—	—	—	—	—	10(0.5)	—	—	—	0(0.5)	—	—
596	*Cirsium scariosum*	—	—	—	—	—	—	—	—	10(0.5)	—	5(0.5)	3(0.5)	—	—	—
459	*Epilobium angustifolium*	—	10(0.5)	10(0.5)	10(0.5)	10(15.0)	10(15.0)	10(15.0)	10(15.0)	—	6(1.8)	5(0.5)	6(1.8)	4(1.3)	10(3.0)	6(1.3)
889	*Epilobium watsonii*	—	5(0.5)	—	—	—	—	—	10(3.0)	—	3(0.5)	—	—	—	—	—
464	*Erythronium grandiflorum*	—	—	—	—	—	—	—	—	—	—	—	3(0.5)	1(0.5)	10(0.5)	—
467	*Fragaria* spp.	10(0.5)	10(15.0)	—	10(0.5)	10(0.5)	5(0.5)	10(0.5)	—	10(37.5)	10(15.0)	5(0.5)	3(0.5)	5(0.9)	10(0.5)	4(0.5)

[1]Code to constancy values: + = 0- 5% 2 = 15-25% 4 = 35-45% 6 = 55-65% 8 = 75-85% 10 = 95-100%
1 = 5-15% 3 = 25-35% 5 = 45-55% 7 = 65-75% 9 = 85-95%

[2]Palatability ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.), and Beecham (1981).

(con.)

APPENDIX C. (Con.)[1]

HERB LAYER GROUP		*Castilleja miniata*				*Epilobium angustifolium*				*Fragaria vesca*		*Carex geyeri*		*Calamagrostis rubescens*		*Thalictrum occidentale*
Herb layer type		CAMI -CAMI	CAMI -FRVE	CAMI -CAGE	CAMI -CARU	EPAN -EPAN	EPAN -CAGE	EPAN -CARU	EPAN -THOC	FRVE -FRVE	FRVE -CARU	CAGE -CAGE	CAGE -CARU	CARU -CARU	CARU -THOC	THOC -THOC
Number of stands		*n* = 1	*n* = 2	*n* = 1	*n* = 2	*n* = 1	*n* = 2	*n* = 2	*n* = 1	*n* = 1	*n* = 3	n = 2	*n* = 3	*n* = 14	*n* = 1	*n* = 5
ADP No.	Perennial forbs															
471	*Galium triflorum*	—	5(0.5)	10(0.5)	—	—	5(0.5)	5(0.5)	10(0.5)	—	—	—	—	1(0.5)	—	6(1.3)
473	*Geranium viscosissimum*	—	—	—	—	—	—	—	—	—	—	5(0.5)	3(0.5)	—	—	—
621	*Geum macrophyllum*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
476	*Goodyera oblongifolia*	—	—	—	—	—	—	—	—	—	—	—	3(0.5)	5(0.5)	10(0.5)	6(0.5)
483	*Hieracium albertinum*	—	5(0.5)	—	—	—	5(0.5)	5(0.5)	—	—	—	—	3(0.5)	1(0.5)	—	2(0.2)
484	*Hieracium albiflorum*	10(0.5)	—	—	—	—	10(0.5)	—	—	—	3(0.5)	—	3(0.5)	3(0.5)	—	4(0.5)
833	*Iliamna rivularis*	—	—	—	—	—	5(0.5)	—	—	—	—	—	—	—	—	—
636	*Lathyrus nevadensis*	—	—	—	—	—	—	—	—	—	—	—	3(0.5)	0(0.5)	—	2(0.5)
499	*Lupinus* spp.	—	—	10(0.5)	10(15.0)	—	5(0.5)	5(0.5)	—	—	7(1.8)	5(0.5)	3(0.5)	1(0.5)	—	—
502	*Mitella stauropetala*	10(0.5)	5(0.5)	—	—	—	—	—	—	—	—	—	—	0(0.5)	—	2(0.5)
505	*Osmorhiza chilensis*	—	5(0.5)	—	—	—	—	5(0.5)	10(0.5)	—	—	5(0.5)	—	2(0.5)	—	10(0.5)
509	*Pedicularis racemosa*	—	—	—	—	—	—	—	—	—	3(0.5)	—	—	5(5.0)	—	4(0.5)
658	*Penstemon attenuatus*	—	—	—	—	—	5(0.5)	—	—	—	—	—	3(0.5)	—	—	—
514	*Penstemon wilcoxii*	—	5(0.5)	10(0.5)	—	—	5(0.5)	10(0.5)	—	—	6(0.5)	—	—	2(5.3)	—	—
519	*Polemonium pulcherrimum*	10(0.5)	5(0.5)	—	—	—	—	—	—	10(0.5)	—	5(0.5)	—	—	—	4(1.8)
522	*Potentilla glandulosa*	10(0.5)	5(0.5)	10(0.5)	—	—	—	5(0.5)	—	10(0.5)	6(0.5)	10(0.5)	—	0(0.5)	—	—
528	*Pyrola picta*	—	—	—	—	—	5(0.5)	—	—	—	—	—	—	1(0.5)	—	2(0.5)
529	*Pyrola secunda*	—	—	—	5(0.5)	10(0.5)	—	—	—	—	—	10(0.5)	—	2(0.5)	10(0.5)	8(0.5)
675	*Rudbeckia occidentalis*	—	5(0.5)	—	—	10(0.5)	—	—	—	10(3.0)	3(0.5)	—	—	—	—	—
*06	*Rumex acetosella*	—	—	—	—	10(0.5)	—	—	—	—	3(0.5)	—	—	—	—	—
542	*Smilacina racemosa*	10(0.5)	—	—	5(0.5)	—	5(0.5)	5(0.5)	10(0.5)	—	3(0.5)	5(0.5)	3(0.5)	4(0.5)	10(3.0)	6(0.5)
547	*Thalictrum occidentale*	10(3.0)	10(0.5)	10(3.0)	10(7.8)	—	—	5(3.0)	10(3.0)	—	10(1.3)	10(1.8)	6(0.5)	6(2.9)	10(15.0)	10(22.1)
562	*Thermopsis montana*	—	5(15.0)	—	—	—	—	—	—	—	—	—	—	2(0.5)	—	2(3.0)
*09	*Tragopogon dubius*	—	—	—	—	—	—	5(0.5)	—	—	—	—	—	0(0.5)	—	—
560	*Trillium ovatum*	10(0.5)	5(0.5)	—	10(0.5)	—	—	5(0.5)	—	—	3(0.5)	5(0.5)	6(0.5)	3(0.5)	—	4(0.5)
551	*Valeriana sitchensis*	10(0.5)	—	10(0.5)	5(0.5)	—	—	5(3.0)	—	—	3(0.5)	5(0.5)	3(0.5)	2(0.5)	10(3.0)	8(0.5)
554	*Viola adunca*	—	10(0.5)	10(0.5)	—	—	—	5(0.5)	—	—	6(0.5)	—	3(0.5)	1(0.5)	—	6(0.5)
557	*Viola orbiculata*	—	—	—	—	—	—	—	—	—	—	5(0.5)	—	2(1.1)	—	4(3.0)

[1]Code to constancy values: + = 0- 5% 2 = 15-25% 4 = 35-45% 6 = 55-65% 8 = 75-85% 10 = 95-100%
1 = 5-15% 3 = 25-35% 5 = 45-55% 7 = 65-75% 9 = 85-95%

[2]Palatability ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.), and Beecham (1981).

(con.)

APPENDIX C. (Con.)[1]

HERB LAYER GROUP		*Castilleja miniata*				*Epilobium angustifolium*				*Fragaria vesca*		*Carex geyeri*		*Calamagrostis rubescens*		*Thalictrum occidentale*
Herb layer type		CAMI -CAMI	CAMI -FRVE	CAMI -CAGE	CAMI -CARU	EPAN -EPAN	EPAN -CAGE	EPAN -CARU	EPAN -THOC	FRVE -FRVE	FRVE -CARU	CAGE -CAGE	CAGE -CARU	CARU -CARU	CARU -THOC	THOC -THOC
Number of stands		*n* = 1	*n* = 2	*n* = 1	*n* = 2	*n* = 1	*n* = 2	*n* = 2	*n* = 1	*n* = 1	*n* = 3	n = 2	*n* = 3	*n* = 14	*n* = 1	*n* = 5
ADP No.	**Annuals, biennials, and short-lived perennials**															
#09	*Arabis* spp.	—	—	—	—	—	—	—	—	—	—	—	—	1(0.5)	—	—
*12	*Cirsium vulgare*	—	5(0.5)	—	—	—	—	—	—	—	6(0.5)	—	—	1(0.5)	—	2(0.5)
902	*Collinsia parviflora*	—	—	—	—	—	—	5(0.5)	—	—	—	—	—	—	—	—
#56	*Collomia* spp.	—	—	—	—	—	—	5(0.5)	—	—	—	—	—	1(0.5)	—	—
914	*Cryptantha affinis*	—	—	—	—	—	—	—	—	—	3(0.5)	—	—	—	—	—
904	*Epilobium paniculatum* (+ *E. minutum*)	—	5(0.5)	—	—	—	—	—	—	—	3(0.5)	—	—	1(0.5)	—	—
930	*Gayophytum decipiens*	—	5(0.5)	—	—	—	—	—	—	—	3(0.5)	—	—	1(0.5)	—	—
886	*Gnaphalium microcephalum*	—	5(0.5)	—	—	—	5(0.5)	—	—	—	—	—	—	—	—	—
663	*Phacelia hastata*	—	—	—	—	—	5(0.5)	—	—	—	3(0.5)	—	—	1(0.5)	—	—
911	*Polygonum douglasii*	—	—	—	—	—	—	—	—	—	3(0.5)	—	—	1(0.5)	—	—
*16	*Verbascum thapsus*	—	10(0.5)	—	—	—	—	—	—	—	3(0.5)	—	—	—	—	—
999	Bare soil	10(0.5)	10(3.0)	10(0.5)	—	10(3.0)	10(3.0)	5(3.0)	10(3.0)	10(3.0)	10(3.0)	5(0.5)	3(15.0)	5(6.1)	—	2(3.0)
Years since disturbance - average		25	12	22	61	6	16	12	14	14	15	70	30	44	90	75
- range		25	9 - 14	22	60 - 62	6	11 - 21	11 - 14	14	14	12 - 18	70	11 - 50	4 - 90	90	5 - 160

[1]Code to constancy values: + = 0- 5%   2 = 15-25%   4 = 35-45%   6 = 55-65%   8 = 75-85%   10 = 95-100%
1 = 5-15%   3 = 25-35%   5 = 45-55%   7 = 65-75%   9 = 85-95%

[2]Palatability ratings are taken from Kufeld and others (1973), Kufeld (1973), USDA-FS (n.d.), and Beecham (1981).

APPENDIX D: SUCCESSION CLASSIFICATION FIELD FORM FOR GRAND FIR/BLUE HUCKLEBERRY H.T.

(Code Descriptions)

Livestock Effects:
- 1-Light Cattle Use (palatable species stable)
- 2-Heavy Cattle Use (palatable species declining)
- 3-Light Sheep Use
- 4-Heavy Sheep Use
- 5-Trampling (soil surface exposed)
- 6-None
- 7-Other—

Fire Effects:
- 1-Stand Destroyed
- 2-Stand Partially Destroyed
- 3-Creeping Ground Fire
- 4-Hot Broadcast Burn (soil exposed by fire)
- 5-Cool Broadcast Burn (soil not exposed)
- 6-Burned Slash Piles
- 7-None
- 8-Other—

Scarification Effects:
- 1-Heavy (soil well churned)
- 2-Light (only duff removed)
- 3-Soil Scraped Away (by dozer blade)
- 4-Soil in Piles >18″ (from dozer)
- 5-None
- 6-Other—

Name: ____________

Plot No.: ____________

Location: ____________

Date: ____________

Livestock effects: ____________

Fire effects: -Age ____________

Scarification effects: -Age ____________

Vegetation Coverage Class:

0-None	3-25 to 50%
T-Rare to 1%	4-50 to 75%
1-1 to 5%	5-75 to 95%
2-5 to 25%	6-95 to 100%

TREES - canopy coverage
Rate coverage by dbh classes: O.G. >18″ / M. 18-12″ / P. 12-4″ / S. 4-.1″

ADP	Species	O.G. >18″	M. 18-12″	P. 12-4″	S. 4-.1″
001	*Abies grandis*	___	___	___	___
002	*Abies lasiocarpa*	___	___	___	___
006	*Larix occidentalis*	___	___	___	___
007	*Picea engelmannii*				
010	*Pinus contorta*	___	___	___	___
013	*Pinus ponderosa*	___	___	___	___
014	*Populus tremuloides*	___	___	___	___
016	*Pseudotsuga menziesii*	___	___	___	___

SHRUBS - canopy coverage

ADP	Species	
102	*Acer glabrum*	___
104	*Alnus sinuata*	___
105	*Amelanchier alnifolia*	___
107	*Ceonothus velutinus*	___
115	*Lonicera utahensis*	___
122	*Physocarpus malvaceus*	___
123	*Prunus emarginata*	___
130	*Ribes lacustre*	
131	*Ribes viscosissimum*	___
136	*Rubus parviflorus*	___
137	*Salix scouleriana*	___
138	*Sambucus racemosa*	
139	*Shepherdia canadensis*	___
142	*Spiraea betulifolia*	___
143	*Symphoricarpos albus*	___
163	*Symphoricarpos oreophilus*	
146	*Vaccinium globulore*	___
		___

GRAMINOIDS

ADP	Species	
303	*Bromus carinotus*	___
304	*Bromus vulgaris*	___
307	*Calamagrostis rubescens*	___
308	*Carex concinnoides*	
309	*Carex geyeri*	___
311	*Carex rossii*	___

PERENNIAL FORBS and FERNS

ADP	Species	
402	*Actaea rubra*	___
415	*Apocynum androsaemifolium*	___
421	*Arnica cordifolia*	___
426	*Aster conspicuus*	
429	*Astragalus canadensis*	___
#15	*Castilleja* spp.	___
459	*Epilobium angustifolium*	___
465	*Fragaria vesca*	
466	*Fragaria virginiana*	___
833	*Iliamna rivularis*	___
636	*Lathyrus nevadensis*	___
499	*Lupinus* spp.	
509	*Pedicularis racemoso*	___
658	*Penstemon attenuatus*	___
519	*Polemonium pulcherrimum*	___
522	*Potentilla glandulosa*	
259	*Pteridium aquilinum*	___
675	*Rudbeckia occidentalis*	___
547	*Thalictrum occidentale*	___
562	*Thermopsis montana*	
		___
		___
		___

ANNUALS, BIENNIALS, and SHORT-LIVED PERENNIALS

ADP	Species	
*12	*Cirsium vulgore*	___
#56	*Collomio* spp.	___
914	*Cryptantha affinis*	___
904	*Epilobium paniculatum*	___
930	*Gayophytum decipiens*	
886	*Gnaphalium microcephalum*	___
663	*Phacelia hastata*	___
911	*Polygonum douglasii*	___
*16	*Verbascum thopsus*	___
		___
		___

TREE LAYER TYPE ____________

SHRUB LAYER TYPE ____________

HERB LAYER TYPE ____________

EXAMPLES OF SHRUB LAYER TYPES IN THE GRAND FIR/BLUE HUCKLEBERRY H.T.

Published as part of—The Grand Fir/Blue Huckleberry Habitat Type in Central Idaho: Succession and Management—GTR-INT-228, 1987

VAGL -VAGL							*Vaccinium globulare*
LOUT -LOUT	LOUT -VAGL						*Lonicera utahensis*
SPBE -SPBE	SPBE -LOUT	SPBE -VAGL					*Spiraea betulifolia*
ALSI -ALSI	ALSI -SPBE	ALSI -LOUT	ALSI -VAGL				*Alnus sinuata*
SASC -SASC	SASC -ALSI	SASC -SPBE	SASC -LOUT	SASC -VAGL			*Salix scouleriana*
RIVI -RIVI	RIVI -SASC	RIVI -ALSI	RIVI -SPBE	RIVI -LOUT	RIVI -VAGL		*Ribes viscosissimum*
CEVE -CEVE	CEVE -RIVI	CEVE -SASC	CEVE -ALSI	CEVE -SPBE	CEVE -LOUT	CEVE -VAGL	*Ceanothus velutinus*

Succession classification diagram of the shrub layer in the ABGR/VAGL h.t.

Layer groups

Vaccinium globulare

Vaccinium globulare* - *Vaccinium globulare

A dominant layer of *Vaccinium* persists beneath this dense tree canopy. No other shrubs are well represented. Unless disturbed, this shrub layer will persist indefinitely through its rhizomatous growth habit.

Lonicera utahensis

Lonicera utahensis* - *Lonicera utahensis

This site was clearcut and scarified by stripping 15 years ago. *Lonicera* resprouted and possibly increased by seed; it is now the dominant shrub. *Vaccinium* is the only other shrub that is well represented.

Lonicera utahensis* - *Vaccinium globulare

This unlogged stand has remained undisturbed for many years. *Lonicera* is well represented, but *Vaccinium* is clearly the dominant shrub. No other shrubs are well represented.

Spiraea betulifolia

Spiraea betulifolia* - *Spiraea betulifolia

This sparse SPBE-SPBE l.t. occurs in a 5-year-old clearcut. The area was well scarified, but only small amounts of *Ribes* and *Ceanothus* germinated from buried seed. *Spiraea* survived the scarification and is the only shrub well represented; it will continue to increase by rhizomes.

Spiraea betulifolia* - *Lonicera utahensis

This SPBE-LOUT l.t. occurs on a site that was clearcut and lightly scarified 9 years ago. *Spiraea* and *Lonicera* both resprouted following the scarification and now codominate the site. No other shrubs are well represented.

Spiraea betulifolia* - *Vaccinium globulare

This SPBE-VAGL l.t. occurs in an unlogged stand which has experienced little disturbance for many years. *Spiraea* remains well represented, but *Vaccinium* is by far the dominant shrub. Clearcutting and scarification of this shrub layer produced the SPBE-SPBE l.t. shown herein.

Salix scouleriana

Salix scouleriana* - *Salix scouleriana

This SASC-SASC l.t. occurs in a 5-year-old clearcut. The site was well scarified, but only an occasional *Ribes* or *Ceanothus* is present. *Salix* has resprouted from stumps and established from seed. It now dominates the site.

Salix scouleriana* - *Alnus sinuata

A ponderosa pine seedtree cut occurred here about 24 years ago. The site was well scarified and *Salix* and *Alnus* both established from seed on the bare soil. Some sprouting from stumps may have also occurred. *Salix* is well represented, but *Alnus* is clearly the dominant shrub.

Salix scouleriana* - *Lonicera utahensis

This site was clearcut and well scarified 12 years ago. *Salix* and *Lonicera* both resprouted from stumps. The *Salix* is well represented but *Lonicera* dominates the site. *Vaccinium* is the only other shrub that is well represented.

Salix scouleriana* - *Vaccinium globulare

This 11-year-old clearcut was only scarified in spots and much of the *Vaccinium* survived. *Salix* established from seed on the bare soil and is well represented, but *Vaccinium* is the dominant shrub. No other shrubs are well represented.

Ribes viscosissimum

Ribes viscosissimum* - *Ribes viscosissimum

An 11-year-old clearcut with thorough scarification produced this dominant layer of *Ribes* from buried seed. Only a trace of *Ribes* is present in the adjacent unlogged stand. This response is common in ABGR/VAGL clearcuts that are well scarified but not burned.

Ribes viscosissimum* - *Salix scouleriana

This site was clearcut and scarified 13 years ago. *Ribes* germinated from buried seed and is now well represented. *Salix* resprouted from stumps and also established from windblown seed. These two shrub species now codominate the site.

Ribes viscosissimum* - *Alnus sinuata

This RIVI-ALSI l.t. resulted from an 11-year-old well-scarified clearcut near the moist extreme of ABGR/VAGL. The *Ribes* from buried seed and the *Alnus* from both sprouts and windblown seed responded to the scarification and now codominate the site.

Ribes viscosissimum* - *Lonicera utahensis

This 14-year-old clearcut was lightly scarified during logging, but most of the *Vaccinium* was killed. *Ribes* (mainly *R. lacustre*) germinated from buried seed and is well represented. The *Lonicera* resprouted from surviving root crowns and now dominates the site.

Ribes viscosissimum* - *Vaccinium globulare

This 10-year-old clearcut was lightly scarified, and much of the *Vaccinium* survived. *Ribes* germinated from buried seed and is well represented. The *Vaccinium* is low in stature but has the greatest canopy cover. *Lonicera* is the only other shrub well represented.

Ceanothus velutinus

Ceanothus velutinus* - *Ceanothus velutinus

This CEVE-CEVE l.t. resulted from a clearcut and broadcast burn operation 14 years ago. *Ceanothus*, in response to the burning, germinated from seed buried in the soil and now dominates the site. *Spiraea* is well represented and increasing beneath the *Ceanothus*. Eventually this shrub layer may progress to a CEVE-SPBE l.t.

Ceanothus velutinus* - *Ribes viscosissimum

This CEVE-RIVI l.t. is the result of scarification without burning 10 years ago. Both *Ceanothus* and *Ribes* germinated from buried seed but *Ribes* is the dominant shrub. *Salix* established on the scarified soil from windblown seed and may eventually dominate the shrub layer. Then it will be a CEVE-SASC l.t.

Ceanothus velutinus* - *Salix scouleriana

This CEVE-SASC l.t. resulted from a 12-year-old clearcut and no site preparation. The prelogged stand had burned 30 years prior to logging and contained residual *Salix*. The *Salix* was rejuvenated by removal of the tree canopy and now dominates the site. The *Ceanothus* may also be residual or may have germinated due to minor logging disturbances.

Ceanothus velutinus* - *Alnus sinuata

This rare CEVE-ALSI l.t. has not yet been found in ABGR/VAGL but occurs here in an ABGR/LIBO h.t. which is similar to ABGR/VAGL. This shrub layer resulted from a clearcut and broadcast burn 10 years ago. *Ceanothus* from buried seed and *Alnus* from windblown seed, or possibly sprouts, now codominate the site.

Ceanothus velutinus* - *Spiraea betulifolia

This CEVE-SPBE l.t. resulted from a seedtree cut and scarification 10 years ago. Scattered *Ceanothus* germinated in response to the scarification. *Ribes* seed is apparently absent in the soil. *Spiraea* survived the scarification and has increased from rhizomes. It now has the greatest canopy cover.

Ceanothus velutinus* - *Vaccinium globulare

This CEVE-VAGL l.t. resulted from clearcutting and slight scarification. This 7-year-old clearcut contains scattered *Ceanothus*, which is well represented, and some *Ribes*. Much of the residual *Vaccinium* survived the scarification and, though obscured by the taller shrubs and trees, has the greatest canopy cover.

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Steele, Robert; Geier-Hayes, Kathleen. 1987. The grand fir/blue huckleberry habitat type in central Idaho: succession and management. Gen. Tech. Rep. INT-228. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 66 p.

A succession classification system based on 92 sampled stands is presented. A total of 21 potential tree layer types, 28 shrub layer types, and 36 herbaceous layer types are categorized by a taxonomic classification. Diagnostic keys based on indicator species provide for field identification of the types. Management implications include pocket gophers, success of planted and natural tree seedlings, big game and livestock forage preferences, and responses of major shrub and herb layer species to disturbances.

KEYWORDS: forest succession, habitat types, plant communities, forest ecology, forest management, silviculture, classification, Idaho

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